Vol. 55 No. 2

BABCOCK
October 1961

Quarterly

of the

National Fire Protection Association

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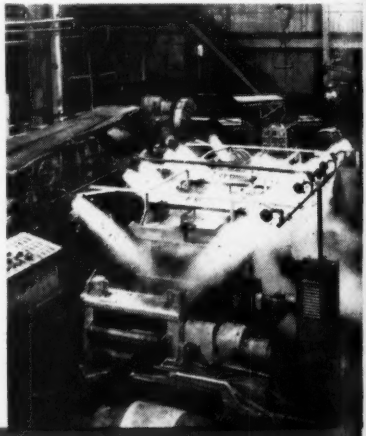

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Vol. 55 No. 2 October 1961

Quarterly

The Standard Technical Journal of Fire Protection for More Than Fifty Years

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Quarterly

of the

NATIONAL FIRE PROTECTION ASSOCIATION

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RENÉE FOSSE, *Editorial Assistant*
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Articles and accounts of fires appearing in the Quarterly are based on material forwarded to the Association. The Association, as a body, does not assume responsibility for the accuracy of the material printed herein.

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Portland, Ore., June 17, 1961. Destruction of this former shipyard building of 440,000-square-foot area caused damage in excess of $4,000,000. Prior to fire (see insert) the building was used by two companies fabricating pipe and truck bodies, and by a grain company for bulk storage.

The fire originated in a lean-to at one end of the building (right end in large photo) and spread throughout the noncombustible structure with wood roof due to lack of sprinkler protection and lack of subdivisions other than metal or cement-asbestos board partitions. Long running distances for fire companies, interruption of electric service to plant fire pumps, grain dust, and paint spray residues contributed to the total loss.

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The Ayer Tannery Fire

Fire, starting in a leather finishing dryer of the Hartnett Tanning Company plant in Ayer, Massachusetts, on June 5, 1961, spread to and across the outside of a wall of the building. Flames then entered open plant windows on three upper floors to overpower the sprinkler protection provided and wipe out the largest industry in the community. Before the flames were extinguished, they also had spread to destroy a rope processing company, which was the town's third largest business, and six neighboring dwellings.

The origin of the fire in an unsprinklered enclosure, deposits of nitrocellulose base lacquer on the outside of the building, the combustible exterior wall surfaces over which the fire spread rapidly, and the hot, dry, and windy weather conditions were the principal reasons why this fire quickly spread out of control. As will be pointed out, the water supply for sprinklers was poor. A strong water supply undoubtedly would have reduced the speed with which the interior of the building was involved. However, the conditions that permitted a severe fire to envelop the outside of the building before adequate fire streams could be placed in operation probably would have meant the end of the tannery and neighboring buildings even if a water supply ordinarily considered adequate for this plant had been available.

Property damage totaled approximately $4,000,000. Effects of the fire

Peter J. Conway

Taken approximately 30 minutes after the start of the fire, this photo shows the ropeworks at far right, the main tannery building in center, and the as yet not involved 1-story machine shop at left.

that cannot be readily measured in dollars included the loss of 414 jobs, loss of living facilities for 35 people, and the many adverse effects on the town's economy resulting from the destruction of two of its principal industries. These indirect losses are still being tabulated, but the editors of the QUARTERLY are planning a subsequent report on the economic effects of this fire on the town of Ayer and its people. This present article reports the factors responsible for the direct property loss.

Ayer, June 1, 1961

Ayer, Massachusetts, had a small permanent population reported in the 1960 census as 3,323 persons. This group of people was about doubled by another 3,000 persons living off-base from the Army's Fort Devens, which is within Ayer's borders. The main industry in Ayer was a leather tanning plant which produced upper leather for women's shoes. This operation provided jobs for 380 persons and a payroll of $1,700,000 annually. The third largest business was a company which stored rope and processed used rope, hemp, and burlap. The rope company employed 35 people.

The tanning and rope plants were located on Bligh Street across from each

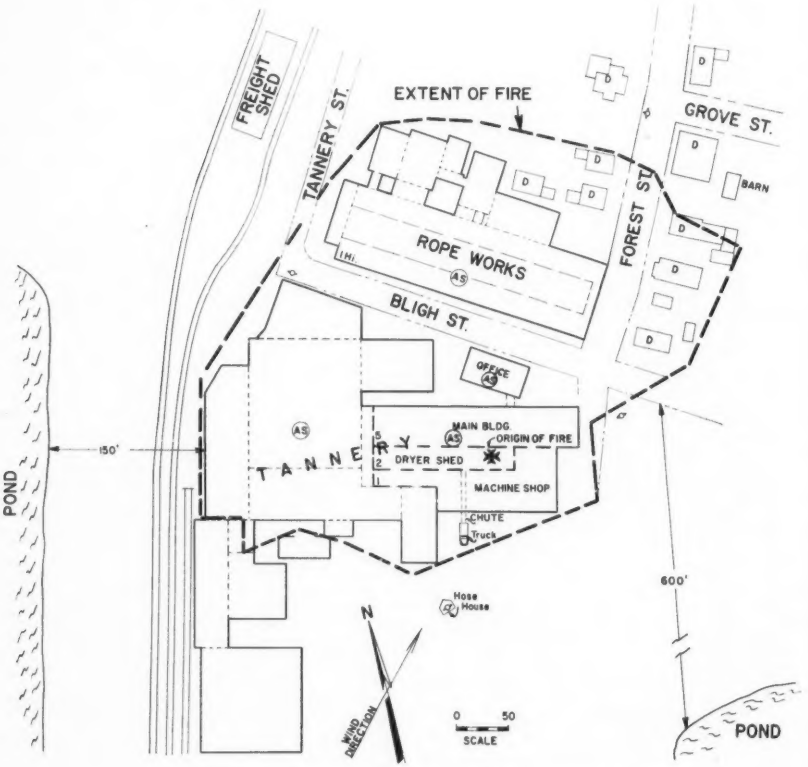

Figure 1. Area destroyed by fire at Ayer, Mass., June 5, 1961.

other, between the intersections of Bligh with Forest and Tannery Streets (see Figure 1). Bligh Street is a 25-foot-wide road providing a separation of only 35 to 40 feet between the two large combustible industrial buildings.

The 40-foot-high rope works building sheltered what was essentially one giant 1,900-ton pile of rope. The rope works building was owned by the International Purchasing Company and was occupied for rope processing and storage for the John A. Manning Paper Company, Inc.

Hartnett Tanning's Buildings

The Hartnett Tanning Company had grown over the years from a single 40-foot by 200-foot, 5-story wooden main building built in the early 1880's to a complex of eleven additions covering a ground area of almost two acres. The building had been sprinklered in 1909, and the additions were sprinklered as they were built. Most of the additions were 1-story masonry, wood-joisted buildings. The office building (between the main building and the International Purchasing Company building across the street) was a 2-story masonry, wood-joisted structure. The Hartnett buildings were all interconnected and formed essentially one fire area with approximately 115,000 square feet of usable floor area.

The 5-story main building was a wooden structure with a ¾-inch asphalt-impregnated sheathing forming the outside wall. Over this sheathing was an asphalt shingle siding. The southwest side of the main building was adjoined by a 1-story addition of wooden construction which was used mostly as a machine shop. A small extension of the second story of the main building had been built on the roof of the 1-story maintenance shop to provide more space for leather finishing operations carried out in the second story (see Figure 2). The extension contained leather dryers and is shown on the diagram as the Dryer Shed.

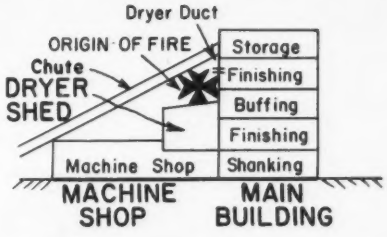

Figure 2. Elevation of tannery building as viewed from east end (Forest St.).

The fourth floor of the main building, where the fire was to start, also contained leather finishing operations. Two automatic spray-chamber-and-dryer coating machines for the water emulsion finishing of leather were located here. One machine had been operating for some years; the other was fairly new. The sprinklered 12-foot by 12-foot spray chamber on each machine was equipped with a water spray in the exhaust and a water tank overspray collector under the conveyor. Each spray chamber adjoined an unsprinklered 6-foot by 50-foot steam heated dryer. Operating at about 150°F, the dryers were protected by an automatic carbon dioxide system supplied by seven 50-pound cylinders. This protection was not judged adequate for this fire exposure, and sprinklers were planned for the dryers but had not yet been installed. Each dryer was vented through three 12-inch ducts to an 18-inch duct which pierced the southwest wall and discharged outside the fourth floor above the second story dryer shed roof.

The leather industry calls the materials it uses in finishing "water emulsions." It was not generally known at the Hartnett Tannery that some of

Peter J. Conway

This remarkable picture was taken about 6:25 P.M., approximately 15 minutes after ignition. It is a scene to the west across the Forest and Bligh Streets intersection. Note the tannery's complete involvment, the burning roof of the rope factory (far right of photo), and the smoking front of the dwelling.

Peter J. Conway

Same view as photo above about two hours later.

the "water emulsions" used with the spraying operation were composed of three parts nitrocellulose base lacquer and one part water. Dustlike in appearance, the highly flammable residue from this lacquer spraying operation was controlled by a vigorous maintenance program involving repetitive housekeeping and water washing of the exhaust from the spray chamber. Despite these efforts highly combustible lacquer dust escaped from the spray booth and dryer to coat the interior of the dryer, the walls of the fourth floor, the roof of the dryer shed and the machine shop as well as the asphalt-shingled wall of the main building. Some residue was even reported on vehicles within 100 yards of the dryer vent.

The Water Supply

Two pumps, drawing from separate deep, gravel-wall wells, supplied the water for this town. One was an electrically driven 750-gpm pump discharging into the 8-inch main through a length of 16-inch pipe. The other was an electrically driven 500-gpm pump with auxiliary gasoline engine drive. It discharged into the same 8-inch main through a separate length of 14-inch pipe. The electrical power for these pumps came by pole and ran down the tannery side of Bligh Street.

Overflow from the town pumps was collected in two large standpipes of 1,000,000 gallons total capacity.

Forty years ago, this water supply provided at the intersection of Bligh

Wide World Photos

This aerial view of the Ayer fire shows the tannery in the foreground, the ropeworks behind, and burning dwellings to the right.

Peter J. Conway

Same general view as shown in photo on page 101, taken about 10 minutes later.

and Forest Streets 1,580 gpm at 20 pounds residual pressure. The year before the fire a test at this same intersection showed a static pressure of 88 pounds and a calculated flow at 20 pounds residual pressure of only 735 gpm. This would provide under ideal conditions only 620 gpm on the fifth floor of the plant with a 15-pound residual, and only 680 gpm on the third floor with a 15-pound residual. This flow, if available for sprinklers only, would have supplied thirty sprinklers on the third floor.

The reduction in available water at this site had not gone unnoticed. In 1957, three fires occurred on the fourth floor of the tannery building. The largest opened about 100 sprinklers and had to be extinguished by fire department hose streams in conjunction with sprinklers. The old type sprinklers in this area were replaced by new standard (spray-type) sprinklers at that time. Also, in October 1956, a fire from a welding torch spread steadily through the rope works, opening 210 sprinklers.

These incidents prompted the companies to attempt to get an improved water supply. Plans calling for a 10-inch water main directly from the town wells to the Bligh Street intersection were scuttled by a farmer who would not give the town an easement. The farmer's reason: the tannery operations forced an enlargement of the sewage disposal system with subsequent increased taxes. There was no indication on reports that a secondary private supply had been considered.

Ayer, June 5, 1961

June 5 was the fifth day of the year in which the official weather bureau temperature rose over 80°F. and the fourth day of the first hot, dry spell of the year. The relative humidity had dropped into the thirties and high twenties during these four days under the influence of the 12–15 mph southwest winds and high daytime temperatures. By 10:00 A.M. on June 5 the temperature rose above 75°F, the humidity dropped below 35 per cent, and the wind speed passed 15 mph. During the day the sun

Chief George Donahue

On Oct. 19, 1956, a fire caused by cutting torch sparks spread on rope fibers through the second story of the rope works. This view, looking east on Bligh Street toward Forest Street, was taken during that fire. The sprinklers controlled the fire severity until hose lines completed extinguishment of the smoldering rope. Eventually 210 sprinklers opened.

beat down, raising the temperature of the black roofing of the machine shop and dryer shed to something over 120°F while the asphalt-shingled siding of the southwestern face of the main building probably reached a similar temperature. Air temperatures were unofficially reported as over 90°F during the afternoon, and the relative humidity dropped to a low of 30 per cent. Due to the high temperatures, almost all of the windows in the main tannery building were open.

6:00 P.M.

By 6:00 the temperature had dropped only to 86°F, and the humidity had risen to only 34 per cent. The wind was still gusty and from the southwest, blowing into open factory windows at an average speed of 16 mph with gusts of 28 mph.

The new spray machine on the fourth floor had been shut down for cleaning during the late afternoon. The old machine was being operated by two general employees for the first time. When they left for their supper break, the old machine was placed on "standby": the steam was on, the conveyor and vent fans were on, but the lacquer emulsion spray was off.

An employee on the fifth floor, shipping leather by sending bundles down an outside chute to a truck driver in the yard below, remained behind when most of the rest of the shift went to the yard for their supper break.

6:10 P.M.

At about 6:10 P.M., the shipper smelled smoke and thought it was from cigarette smoking below. At just about this time, the truck driver heard a muffled explosion and looked up to see flames and flaming debris issuing from the old dryer vent at the fourth floor level. This flaming debris ignited the lacquer residue on the dryer shed roof. He yelled to nearby employees and to the man on the fifth floor. The employees in the yard dragged two 2½-inch hose lines from the yard hose house over the truck cab to the roof of the 1-story addition and tried to play them on the burning dryer shed roof. While they had been laying these lines, the fire had extended up the siding to the roof of the main building and had also spread about 30 feet horizontally.

6:17 P.M.

As the hose lines on the roof were being brought into play, the sprinkler alarm began to ring; this automatically tripped the master fire alarm box on the corner of Forest and Bligh Streets. At about this same time, the fire alarm box was manually tripped by an employee. Employees on the third floor had brought a 1½ inch hose into operation on the dryer shed roof. This hose was supplied by a 3-inch feed from below the alarm valve of the sprinkler system. A little 4-foot-long stream came from the nozzle. The line was dropped; and, as the employee holding the nozzle reentered the third floor to escape, he was

wet with water from the sprinkler system.

It is estimated that the two 2½-inch plant hose lines being used on the roof of the machine shop took about 400 gpm from the water supply, leaving only enough water for twelve sprinklers on the third floor. The wind drove flames into the third floor through the open windows, probably causing many times this number of sprinklers to open within the space of a minute or two after the hoses were put into operation. One employee coming down the interior stairway reported seeing no fire in the fourth floor but seeing flames coming in the third floor windows and seeing also what appeared to be a bad water leak on the third floor — indicating that sprinklers were getting practically no effective water.

6:20 P.M.

The first responding engine of the Ayer Fire Department was manned only by the fire department dispatcher. He found the flames already above the roof of the eastern end of the main building. The driver laid one hose from the hydrant at the corner of Bligh and Forest Streets and another from a hydrant further north on Forest Street to the south side of the machine shop. Meanwhile, the chief, responding to the audible signal from his auto sales agency, saw the smoke and flames from a distance and radioed for outside help. The dispatcher at nearby Groton, Massachusetts, relayed the call to three fire departments.

6:24 P.M.

After arrival at the plant the chief radioed for additional help. Three more departments were summoned. The water main pressure had dropped to below 70 psi at the public works office. Because of the location of the public works office on the water distribution system, the office undoubtedly recorded pressure drops much less severe than actually occurred in the fire area.

6:30 P.M.

Less than twenty minutes had elapsed now from the first smell of smoke. Peter Conway, a photographer who lived up the street from the tannery, had taken the upper photograph shown on page 104. The men who had been operating hose lines on the roof of the main addition were forced to abandon their posts. As they did so, the first mutual aid pumper rolled to the fire scene. The main building was fully involved, radiating heat energy onto the roofs of surrounding buildings upwind and down. The rope factory roof had ignited, and the dwelling across the intersection to the east of the main building was also on fire.

Radiated heat had weakened the electric wires on Bligh Street so much that they had collapsed. This de-energized the electric town pumps so that now the only water was that available from the two town standpipes. The town water pressure dropped suddenly about this time to less than 40 psi.

6:42 P.M.

The fire had now involved most of the rope factory and tannery and was spreading to other nearby buildings. Some parts of buildings were starting to collapse. The fire chief requested all available aid.

More towns were called for help, and others were responding voluntarily when they heard about the fire. Most of the pumpers took suction from two nearby ponds. One of the ponds was across the railroad tracks to the west, and the other was south of the plant. From these positions, hose lines were laid to confine the fire to the two plants and the six dwellings involved.

7:00 P.M.

Fire fighters from additional towns helped to lay more hose lines. The town's water pressure continued to drop. It was at 16 psi when the auxiliary gasoline engine drive on the 500 gpm pump was started, but this raised the pressure to 19 psi for only a few minutes.

7:30 P.M.

Thirty-eight hose lines were now in use, and several deluge guns had been set up as monitor streams to cool the fire. Twenty-one pumpers were in use supplying these heavy lines with water from the pond and the water main. All roofs on the involved buildings were down, and sparks from the inferno were spreading downwind. A helicopter was patrolling the downwind area, reporting spot roof and brush fires from flying brands. The pressure was now down to 10 psi in the town water mains. In addition to the broken sprinkler piping from the collapse of the roofs of the buildings, water was also being lost, on the northeast end of Bligh Street, from a hydrant that had been knocked over by a piece of fire equipment fairly early in the fire.

8:00 P.M.

The fire was now confined to the area of involvement and was declared under control. Work was started to isolate the broken mains and shut off sprinkler valves.

Midnight

By midnight the pressure in the town water system had returned to almost 57 pounds. Relief crews, that had been called in, stood by and pumped into the ruins during the next day.

Ayer, June 6, 1961

Wetting down of the fire area continued through the day.

Investigation of the dry pipe valves in the ruins indicated that all of the valves had tripped properly and were still on latch.

During the next few days all but 7 of the 380 tannery employees were paid off for the rest of the current work week and for accumulated vacation time. The rope works discharged 30 of its 34 employees.

Record Protection

The records in the Hartnett Tannery were stored in two antique iron safes, ordinary metal filing cabinets, metal strong boxes, metal card files, and two insulated record containers. All of these records were destroyed except for those stored in the insulated record containers. Salvaged records constituted a 3-month payroll record and inventory records irreplaceable for validating the loss claims.

The most important records lost were the individual work histories of employees.

Stock records were laboriously reconstructed from the files of suppliers

Courtesy Shaw-Walker

The antique iron safes in the tannery appeared in good condition after the fire, but the insurance policies inside had been destroyed.

through extensive correspondence and searches of the suppliers' shipping records.

The old iron safes were purchased by the Hartnett Tannery along with the property of the Ayer Tannery back in the early 1940's Their history and ratings, if any, are not known. The insulated filing cabinets were purchased within the last 10 years and carried a Class D rating.

All records were lost in the International Purchasing Company, as no record protection equipment was available.

The Indirect Losses

The indirect losses of the fire are now being studied by a graduate student at the Harvard Business School. The study's main objective will be to determine if there are steps that can be taken to lessen the impact of indirect losses. To achieve this objective, an economic model will be built of Ayer's economy as it existed before the fire. This model will include all phases of Ayer's economic life.

From the model and from evaluating the economic conditions after the fire, it should be possible to abstract the effects of the fire on each segment of the economy and to measure the effect of a change in one part of the economy on operation of another part. It is planned that a report of this study will be made available to the NFPA and will be summarized in a later edition of the QUARTERLY.

Courtesy Shaw-Walker

A 3-month payroll record and records needed to reconstruct the equipment inventory were saved from fire and impact through their storage in these Class D fire-resistive insulated filing containers.

Courtesy Shaw-Walker

This ordinary steel filing cabinet had contained correspondence and supply records before the fire. The small metal card file held U. S. Savings Bond records.

Retroactive Application of Fire Laws

By Honorable John M. Wise, Judge
Third Judicial Circuit Court of Michigan

It is the responsibility of the legislative division of government, such as a state legislature or city council, to protect the general public by the passage of fire safety laws under its governmental police powers.

Fire marshals are best qualified to know from practical experience and statistics what laws should be submitted to legislative bodies for the public's protection. They should be aggressive and bold in their suggestions to the lawmaking bodies. They should not forget that they are dealing with human lives in addition to the property losses.

In the United States, NFPA figures show that in 1960, 11,350 lives were lost and that properties valued at $1,544,200,000 were destroyed by fire. Certainly there is an element of national disgrace in the persistence of conditions which permit these sickening tragedies to happen.

Of course, laws alone are not the answer. No matter how much effort is exerted by public bodies, no matter how good the fire departments are, no matter how many drives are conducted to educate the public, nothing can take the place of the individual's responsibility for the removal or prevention of fire hazards.

Adequate laws for fire safety measures are a necessity and a great step in the right direction. However, what good are the laws if they are not enforced? Laws on the books without compliance will not make any building less hazardous.

Enforcement, then, is the key — good, hard-hitting, reasonable, indiscriminatory enforcement.

Fire Safety Laws Are Retroactive

It is the present-day safety regulations that are all-important, not those in effect when the building was built thirty or forty years ago.

That the building or buildings were constructed pursuant to a valid permit issued under a then-existing law is somewhat of a factor in favor of the owner. While apparently there has been some thought that there may have been constitutional restrictions (on the application of subsequently enacted laws), this contention has been rejected.

The Supreme Court of the State of Washington, in *The City of Seattle* v. *Hinkley*, said it very simply:

". . . and there is no merit in the contention that the respondent had an inherent or vested right because he has complied with the law existing at the time he built. There is no such thing as an inherent or vested right to imperil the health or impair the safety of the community. But, to be protected against such impairment or imperilment is the universally recognized right of the community in all civilized governments; a protection which the government not only has a right to vouchsafe to the

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Presented at the Annual Meeting of the Fire Marshals Association of North America, held at Detroit, Michigan, May 15, 1961.

citizens but which it is its duty to extend in the exercise of its police power. . . . The people have a right to the safest method that can be found and determined by the legislature.

"Conditions in cities in relation to buildings are constantly changing, dangers from fire are increasing by reason of the change in the construction of buildings, and for many other reasons which might be conceived. In addition to this, mechanical science is making known safeguards, apparatus, and methods of extinguishing fires which were not known before. . . . It would be a sad commentary on the law if municipalities were powerless to compel the adoption of the best methods for protecting life in such cases simply because the confessedly faulty method in use was the method provided by the law at the time of its construction."

Quoting from statements of the Supreme Court of the State of Michigan and State of Georgia:

"The constitutional prohibition of the passage of retroactive laws refers only to retroactive laws that injuriously affect some substance or vested right and does not refer to those remedies adopted by a legislative body for the purpose of providing a rule to secure for its citizens the enjoyment of some natural right, equitable and just in itself, but which they were not able to enforce on account of defects in the law or its omission to provide the relief necessary to secure such right."

Compliance under Due Process

The right to the full and free use and enjoyment of property in a manner and for a purpose as the owner may choose, so long as the purpose is not for the maintenance of a nuisance, injurious to others, is a right of which the owner may not be deprived by government without due process of law. However, an owner of land is not deprived without due process of law when its use is injurious to others and has a substantial relation to public health, safety and welfare and the uses of land may be limited under the police powers of a governmental agency.

In England, where due process concepts were applied only as guards against executive usurpation and tyranny, restraints could be fastened upon executive authority with precision and detail. But in America, as due process principles have become bulwarks also against arbitrary legislation, it would be incongruous to measure and restrict them by the ancient customary English law. Rather, they must be held to guarantee, not particular forms of procedure, but the very substance of individual rights of life, liberty, and property.

Because of its flexible character, due process is the legal formula through which American courts have rationalized legislative restrictions on individual freedom which are in accord with judicial notions of fairness and public need but have struck down as unconstitutional those measures which outraged judicial sensibilities. This is a key concept in the establishment of constitutional limitations by judicial review.

Court Support of Police Power

Police power is simply the power of government to take appropriate action to protect and foster the public welfare.

It is one of the residual powers retained by the states in the American constitutional system.

Traditionally, the police power has been employed to deal with nuisances, to combat the spread of disease, to secure public safety, and to safeguard public morals.

Legislative regulations adopted to safeguard public safety and order seldom

present problems to reviewing courts. One need mention only such familiar types of restrictions as those affecting the muzzling of dogs, the carrying of concealed weapons, the transportation or storing of explosives, the control of fire hazards in buildings, or the promotion of safety in highway and rail traffic.

Former Chief Justice Hughes indicated the judicial attitude to regulations when he indicated that, because compliance is burdensome, there is no reason to set aside the act of the legislature when the subject lies within the police power of the state.

Presumed Validity of Safety Laws

In addition, there is the presumed validity concept.

In other words, a state statute or city ordinance is presumed to be constitutional, so that enforcement officers of fire safety laws need not tread in fear. The burden is upon the contestant who does not wish to comply with the safety law.

As it must be said, before an ordinance can be declared unconstitutional, the provisions must be clearly arbitrary and unreasonable, having no substantial relation to the public health, safety, morals, or general welfare.

The concept of the public welfare is broad and inclusive. Construction of property in full compliance with existing laws does not confer upon the owner an immunity against exercise of the police power.

Thus, a 1944 amendment to a multiple dwelling law, requiring installation of automatic sprinklers in lodging houses of non-fire-resistive construction erected prior to said enactment, does not, as applied to a lodging house constructed in 1940 in conformity with all laws then applicable, deprive the owner thereof of due process, even though compliance entails an expenditure of $7,500 on a property worth only $25,000 (*Queenside Hills Co.* v. *SAXL*, 328 U. S. 80 (1946).

Statutes cannot be declared void because they embody retroactive features unless they violate some provision of the Constitution.

The Thomas Hotel Fire

The February issue of NFPA *Fire News* contains a report of the fire at the Thomas Hotel in San Francisco, where 20 of the 135 guests lost their lives, and 30 were injured. The report indicated that the San Francisco Housing Code requires stairway enclosures in hotels, but that at least up to the time of the fire, it had not been possible to enforce this requirement as to owners of hotels erected prior to 1947, when the Code was adopted. The Thomas Hotel was erected in 1913.

Such a position seems ridiculous. The safety features on buildings and places of assembly in 1913, where the public safety and welfare were involved, are entirely antiquated as compared with present-day standards of safety. To say that the owner of property had a vested interest to the detriment of the health, welfare, and safety of the general public is indeed erroneous thinking. Here is a case, in my opinion, of lack of enforcement. After these tragedies occur and the lives are lost, the press and public officials become indignant, but if there had been good enforcement, the tragedies would never have occurred.

Enforcement in Detroit

In the city of Detroit there is an ordinance relative to the enclosure of open stairways. The fire department even forced the city of Detroit to enclose the open stairway in the old city hall. It, of course, was not easy, but the persistence of the fire department's enforcement division finally forced the city

fathers to expend the necessary sums of money to enclose the stairways. In Detroit our fire department has built an enviable reputation. As a result thereof, all of the citizens in this community reap the benefit, not only in the safety that is accorded them as a result of top enforcement, but also the benefits that result, for example, in the pocket reduction of fire insurance costs. Also, there is a fine relationship between the fire department and our courts that handle city ordinance and state statute violations because of the reasonable, indiscriminatory manner in which enforcing officers present their cases.

English Common Law Concept

It must be recognized that the English common law, from which our law is derived, was part and parcel of a social system in which the landowners were the backbone, and that it was inevitable that, in such a legal climate, supreme importance would be attached to proprietary interests.

It was the feudal conception that the landowner was sovereign within his own boundaries.

Courts Increasingly Liberal

Berman v. *Parker*, decided in 1954, was a case involving the constitutionality under the Fifth Amendment* of a slum clearance and development program in the District of Columbia. Justice Douglas, for a unanimous court, accepted esthetics as a proper public purpose in its own right. The court said that:

"Public safety, public health, morality, peace and quiet, law and order, are some of the more conspicuous examples of the traditional application of the police power of municipal affairs. Yet they merely illustrate the scope of the power and do not delimit it. . . . Miserable and disreputable housing conditions may do more than spread disease and crime and immorality. They may also suffocate the spirit by reducing the people who live there to the status of cattle. They may indeed make living an almost insufferable burden. They may also be an ugly sore, a blight on the community which robs it of charm, which makes it a place from which men turn. The misery of housing may despoil a community as an open sewer may ruin a river. . . . The concept of the public welfare is broad and inclusive. . . . The values it represents are spiritual as well as physical, esthetic as well as monetary. It is within the power of the legislature to determine that the community should be beautiful as well as healthy, spacious as well as clean, well-balanced as well as carefully patrolled."

If the letter and spirit of this decision are followed by the courts of the land, then esthetics will have been recognized as a full-fledged partner with health, morals and safety in measuring the breadth of the police power and the public welfare. So why should fire marshals be concerned about hard-hitting fire enforcements when this is the feeling of the highest court of the land — The United States Supreme Court?

A case that was reported in January, 1961, in *The Northeastern Reporter*, and that had been decided by the Supreme Court of the State of Illinois, is an example of how the courts in the land are becoming more liberal (*Dini* v. *Naiditch* 170 N. E. 2nd 881). This was an action by a fireman and his wife against the owner and lessee of a building made up of several stores and three floors of hotel rooms, known as the Green Mill Hotel. There were approximately 27 rooms.

*The Fifth Amendment states, in part, that no one can be deprived of life, liberty, or property without due process of law.

One case was for injury and the other case was for the wrongful death of a city fireman, allegedly caused by defendant's negligence and statutory violations in the maintenance of the premises in that the landowner failed to provide fire doors and extinguishers, permitted the accumulation of trash and litter in the corridors, and stored benzene in close proximity to inadequately constructed stairways, etc. In the lower court the jury came out with a verdict awarding damages of $235,000 for the personal injuries and the loss of consortium, and $20,000 for the wrongful death.

The judge of the lower court then set aside the verdict and granted a motion *non obstante veredicto* on the ground that there was no basis of liability since the fire ordinances violated by defendants were not enacted for the benefit of firemen. (This is the old theory of assumed risk; in other words, a fireman takes the job knowing the hazards.)

The Supreme Court of the State of Illinois reversed the lower court and ruled that an action may be maintained against a landowner for failure to exercise reasonable care in the maintenance of his property, resulting in the injury or death of a fireman rightfully on the premises, fighting a fire at a place where the fireman might reasonably be expected to be.

Violation of a state statute or ordinance designed for protection of human life or property is *prima facie* evidence of negligence. In Michigan the violation of a state statute is negligence *per se*, which means in and of itself.

Consequently, the Supreme Court of Illinois said it was a proper matter for the jury to determine whether the violations of the state statutes or city ordinances were a proximate cause of the injuries sustained, and of the death in the one case, and sent the cases back for the entry of judgment in accordance with that opinion; so that this case really decided that landowners and operators of a building are liable to city firemen for the negligent maintenance of their premises in violation of certain fire ordinances. This reversed the last previous decision considered by the Supreme Court of Illinois, which was decided in 1892, in which the same problems were determined. This case also set forth the rule that at least firemen entering into premises had a right to assume that the law had been complied with. Even prior to this decision, there are any number of decisions in the various states wherein the courts have held that firemen were entitled to be warned of hidden dangers or unusual hazards known to the landowner or occupant.

You must remember that this is the thinking of the courts in negligence cases, so you can well understand the courts would be more forceful in their opinions in upholding laws passed and the enforcement of these laws for the protection of the general public as safety measures.

Courts all over the land have held that restrictions on the use of land and buildings (whether by zoning, safety, fire, or health ordinances), that have such a substantial relation to public health, safety, and welfare as not to be so unreasonable, arbitrary, or discriminatory as to deprive landowners of property without due process of law, are constitutional.

The rights of the individual owner must be subordinated to the general good. This is democracy.

Automation — A Challenge to Fire Protection Engineers

By Warren J. Baker

Manager, Technical Dept., Insurance Co. of North America
President, Society of Fire Protection Engineers

Automation will affect the work of every fire protection engineer. Recent articles have dealt with automation in eighteen different occupancies including warehouses, foundries, hot strip mills, coal mining, bridge fabricators, glass plants, and the food industry. All have plants which already have adopted automation to run a portion of their operations, if they have not gone completely automatic. Any fire protection engineer who has not already been confronted with the problems introduced by automation will do so in the near future.

Data processing machines present fire protection problems associated with the machines themselves and also problems for those industries which have converted their operating methods to automation.

This paper will dwell on the problems of industrial fire protection created by automation. These include problems in detection, communication, control, prevention, extinguishment, and use of manpower. The fire safety measures that should be considered in connection with protection of the data processing machines themselves have been thoroughly studied by the NFPA Committee on Electronic Computer Systems. The committee's recommendations are available in the Tentative Standard for the Protection of Electronic Computer Systems (NFPA No. 75-T).*

*In its present tentative form, No. 75-T is not an official standard of the NFPA. Copies are available from the NFPA Publications Department for review and comment. Price 50 cents.

Automation Defined

Automation is a continuous and integrated operation of a production system using electronic or pneumatic equipment to regulate, coordinate, and control quantity and quality of production.

Simply stated, automation is accomplished through the use of computers, with the less complicated systems being connected directly with instruments which keep a continuous log or performance record to advise human operators how to get the best out of the machines or process.

The very elaborate computer controls employ the so-called "closed-loop" system where the lightning-fast calculations of a computer and the information-gathering network of instruments and controls supplant the brains, nerves, and hands of men responsible for the running of a unit process or an entire plant. This includes a "feed-back" operation wherein the computer, after receiving a signal from an instrument, feeds back from a memory tape an instruction for an automatic change in the operation in order to maintain proper control with required safety.

Analog and Digital Computers

Two types of computers are in general use. The analog computer is a mechanical or electrical device that is set up as a model analogous to the process to be described or the problem to be solved. It deals with comparative values, not

hard figures, and its results show as lines on a graph, voltages on a meter, or lights on a panel board.

The digital computer essentially is an extremely fast adding machine which turns out the results of arithmetical calculations necessary in controlling the operation or process.

Programing

Both analog and digital computers are needed in some processes. They must be "programed" in such a way that they can produce a desired result from the data they receive. In programing, a person thoroughly familiar with the plant process makes a plan which will translate the language of the industry's engineer into the language which the computer will understand. This involves a statement of information inputs, an outline of the arithmetical steps and logical procedures to be performed, and, finally, a statement of the information outputs. After the statements have been diagramed to indicate pictorially the flow of information, the program must be translated into a detailed set of coded instructions such as *read*, *compare*, *add*, *write*, or *cct* — all of which is stored in the computer memory.

The more common computers will have a capacity of 300 to 500 process variables, while the very large and specially designed can handle up to 5,000.

Computer control will include such frequent operations as sampling, sensing, measuring, interpreting, computing, and translating readings of many instruments, all scanned at regular intervals and with the reports made in computer language.

With the possibility of adopting partial or complete automation to almost any type of process, it can be readily understood that, except in a few cases, no package computer systems are available, and, therefore, they must be tailored to the needs of the industry or process under study.

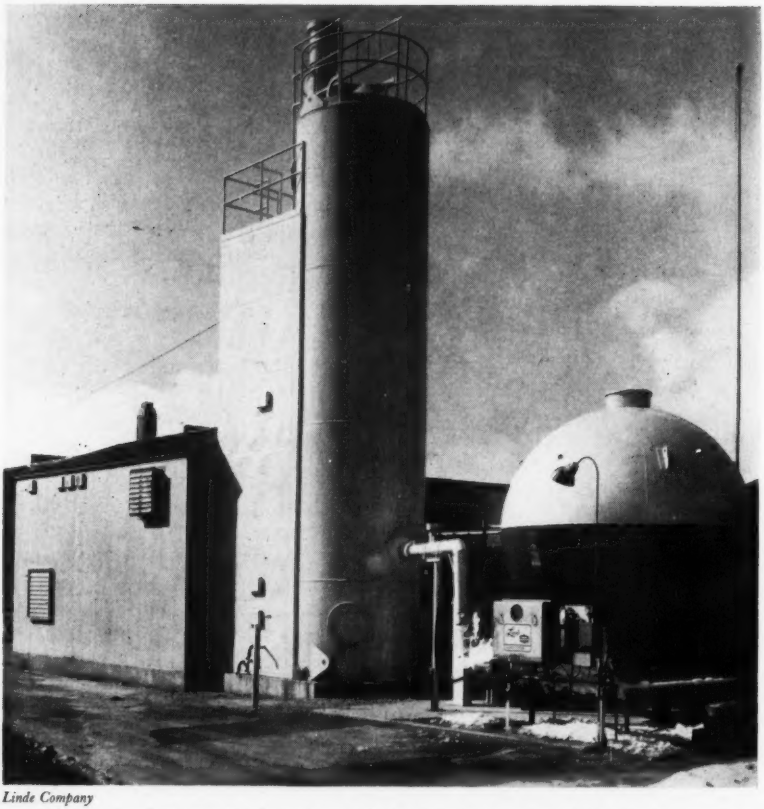
Protection a Part of System Design

It is important that management of a plant to be converted to automatic operation be aware that the fire protection engineer should be consulted during the planning stage.

Once the computer has been designed, installed, and the programing worked out, it is virtually impossible to add, at a later date, all necessary controls for sound fire protection practices.

Dependability of Computer Systems

At present, according to the experts on these systems, computers are sufficiently reliable to do a good job of safety control, but all instruments and actuators are not yet completely dependable. It has been reported that in making a study of process interruption failures, 60 per cent were attributed to failure somewhere in the automatic system and not in the computer itself. Both the Linde Company, a Division of Union Carbide Corporation, and the Atlantic Refining Company, in commenting on their use of automation, have stated that the greatest number of plant shutdowns were caused by failure of the monitoring system to function properly. While no fire or explosion losses were involved, they could have occurred. This experience means that in many cases two recommendations must be considered. First, for fire and explosion control, a separate monitoring system should be provided which will operate independently of the process control system. Very often the analog computer will not have sufficient "variable" capacity, in addition to that necessary for process controls, to include all safety controls such as fire



Linde Company

This unattended, completely automated air separation plant of the Linde Company operates without attendants. It is visited by company personnel only once a week.

and explosion alarms, and extinguishing agent releases. Second, a duplicate control system may have to be provided to take over in the event of a failure in the other.

As an example of this need, consider control cables and instrument tubing running between the computer and operating equipment. These are usually bundles of polyethylene tubing, a plastic which burns readily. Consider also, that if there is not an unusually high degree of maintenance of the entire control system including every single instrument, malfunction can occur. One failure due to a short circuit in a cable or a poor contact of a recording instrument could result in the destruction of an entire plant.

Hazardous Atmospheres

Electronic type computers should never be located in areas subject to flammable atmospheres or dust. In some industries, such as natural gas pipeline transportation, remote pumping stations are pneumatically operated. Pneumatic computers eliminate entirely the heat and spark hazards of electronic equipment.

Records of fire and explosion losses, where process control by automation were involved, are not too many, and even in these cases, it cannot be accurately determined if the loss was caused by malfunction of the system. The explosion at Kingsport, Tennessee,* in October 1960 occurred in a remote control partially automated plant. There was no malfunction of computer controls.

On the other hand, at a chemical plant in Kentucky, the process was under partial control of the computer and was set up with built-in instructions to sound an alarm and lock the valves in a closed position in case something unusual happened. The unusual did occur when a tube in the cracking still failed. The computer continued to allow fuel to be pumped into the tube, and, of course, through the crack in the tube to the fire box. As is too often the case, the operator in that instance was in the cafeteria having his coffee break, so did not hear the alarm. At the time of this particular loss, the process was not completely under the control of the computer, but since then, additional instructions have been programed into the controls and the computer will now shut down the entire process if a tube or similar failure occurs.

Protection in Automated Shops

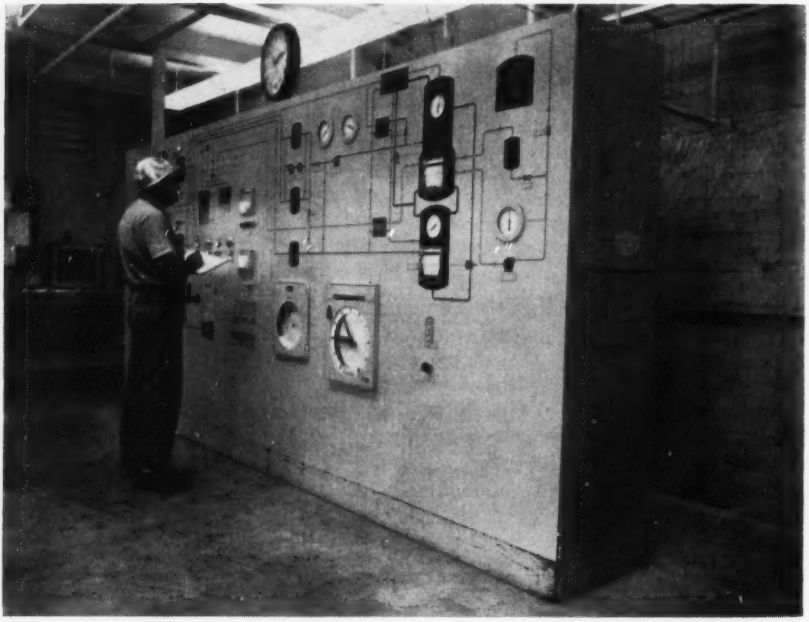
From the viewpoint of the fire protection engineer, one of the simplest problems can be found in the automated machine shop. Here automation is defined as "boss machines sending orders to slave machines" and this is usually accomplished by a separate computer controlling every internal operation of a single machine. Since the entire milling or similar operation is completely programed, there will be no need for an operator except possibly to start and stop that particular process or to make necessary gaging. Possible troubles which should be monitored include jamming of materials or bearings and of other friction points which are always subject to overheating. If there is no employee in attendance, these trouble points can remain undetected until fire results from sparks or friction. Maintenance, especially when flammable cutting oils or lubricating oils are employed, is an old problem, but it now becomes more serious through use of automation with no operator in the area.

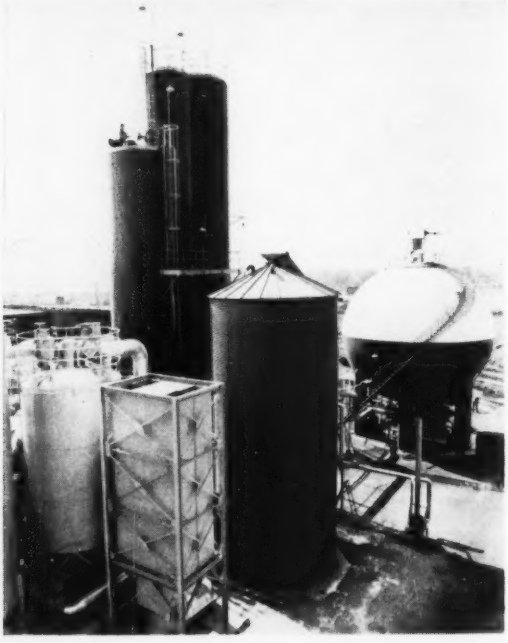
Refineries and Petrochemical Plants

Oil refineries and petrochemical plants are particularly adaptable to automation, not necessarily in their entirety, but usually by units. Here great reliance must be placed on instrumentation, especially since automation eliminates such human operations as hand gaging, opening and closing of valves, or checking on possible runaway reactions. The problem really becomes complex in designing computers to balance or determine chemical reactions, kinetics, heat and mass transfers, process dynamics, and distillation — all controlled automatically with many of them becoming the focal point for a possible fire or explosion in case of malfunction.

In this kind of an operation, measuring devices or instruments must report to the computer such variables as changes in temperature, pressure, levels of liquids or solids, flow or movement of liquids, and radiation. It is of interest to mention here that new and more accurate means of instrumentation are rapidly being developed. Radio impulses are being used for measuring the levels of liquids and solids. For other jobs, sonic impulses or ionization are

*For report see the January 1961 QUARTERLY, p. 264.





Linde Company

The Linde Company's automated air separation plant (left) is attended at all times. The control panel for the plant (above) is arranged in the form of a flow diagram so that the functioning of the entire air separation cycle can be checked visually.

being employed, while spectroscopic methods have become quite common through the use of radio frequency or infrared and X rays.

Automation in such complicated processes must substitute for the eyes, ears, nose, and common-sense knowledge of many people in order to be able to detect trouble in any area however remote, stop the process if necessary, sound the alarm, eliminate the trouble, and release any extinguishing system if fire and explosion have become possibilities. It is estimated that, within 10 years, 75 per cent of the larger refineries and chemical plants will be operating through automatic control systems.

When it is considered that many of these plants will be operating only with 10 per cent to 20 per cent of the previous labor or perhaps with still less, or that a malfunction can occur in any of the hundreds of recording or measuring instruments or in the computer and its nerve channels, or that there is the possibility of something going wrong in the process itself, it can readily be seen that the fire protection engineer has a real problem to contend with.

Pipeline Automation

Pipelines for both gas and oil are particularly adaptable to automation. Between 60 per cent and 80 per cent of the 1961 expenditures of pipeline operating companies are earmarked for automatic control, and already 37 per cent of oil pipelines are controlled remotely. In a typical gas transportation company installation, you will find a pipeline extending about 650 miles that will have six pumping and two control stations. In the control stations or satellites, all operations and faults will be monitored through charts and lights on the control boards to give proper notification to the human operator in attendance.

In some cases the pumping stations are pneumatically operated, but, where internal combustion engines or electricity are used for power, it is necessary that proper attention be given to fire wall cutoffs and similar normal fire protection recommendations. In all remote pumping stations, such potential operating faults as changes in temperature of lubricating oil, bearings, engine exhausts, and cooling water, as well as the speed of the engine, are all monitored. In case of any difficulty, the human operator in the control station can shut down that particular pumping station. These signals or messages can be carried or communicated from the pumping to the control station by the usual transmission lines, but microwave systems have become increasingly popular. Some of the pipeline companies have already started to place their remote pumping stations on closed-loop or completely automatic systems, and in these cases, the computers are programed to stop the pumping operation and perform the necessary safety functions in case of difficulty.

Electric Generating Plants

Electric utility officials are evidently completely sold on the use of computer control, and, since management must take every precaution to avoid a plant shutdown, they are very conscious that safety controls must be included. This year at least six electric generating stations involving automation are under construction, and an equal number are up for bid. The Louisiana Power and Light Company recently placed in operation a steam plant with an output of 230,000 kilowatts. Despite the size of this generating station, the entire plant requires the services of only three men.

The Iowa-Illinois Gas and Electric Company in Davenport, Iowa, has recently completed automatic installa-

tions in four substation buildings. Formerly each of the substations required the attendance of two full-time operators, but after the new system was operating, it was possible to transfer the men to other jobs and leave the substations completely unattended. Considerable thought was given in selecting the supervisory control and protective equipment. For example, an automatic carbon-dioxide system was installed covering all major pieces of equipment in the building along with necessary signals for sounding fire alarms. Should a fire occur in the building, in switching gear, or in one of the transformers, a signal is transmitted to a light on the supervisory control board in the main office of the utility, and in addition, a gong rings at the substation. A study is presently being made by this company of the possible use of smoke detectors wherever plants are being converted to automation, as it is believed that these devices will be more sensitive in detecting the start of an electrical fire.

The Public Service Company of Indiana is preparing to change its $15,000,000 Noblesville electric generating station to automatic operation, resulting in the attendance of four men instead of the present work force of twenty-five. The company also is studying plans to provide automatic smoke detectors and fire extinguishing equipment in all major areas. These will be integrated with gong alarms and a panel light board in the plant office and general control center.

Vital operations of electric generating plant equipment that should be monitored in addition to output control are bearing lubrication, temperature of bearings, volume, pressure, and temperature of hydrogen in cooling systems, and speed of turbogenerator. One of the major causes of large losses in electric generating plants is the mechanical breakdown or disintegration of the turbine generator spindle. Human operation has not been able to anticipate these breakdowns, and it is hoped that properly monitored instruments may be developed to do so.

Oxygen by Automation

The Linde Company has made considerable progress in providing automatic regulation and control of its unattended oxygen plants where the entire building is normally locked with no one in attendance except for the weekly or occasional daily inspection. Process monitors, the key to an unattended plant, are provided for items which would normally be observed by the operator. Sufficient instrumentation is provided to operate and control the process and protect the equipment in case of malfunction. If a serious malfunction occurs, the specific piece of equipment or the entire plant will be shut down automatically. At present, the Linde Company is operating over 30 of these plants with complete automation, but prior to this conversion, an extensive development program was undertaken. This program included two years of pilot plant operation preceding the installation of the first production unit.

All of the process controls are basically pneumatic, although the monitoring equipment is essentially electrical. The prime consideration in instrument selection was its reliability. In these plants, the monitoring system is separate and independent from the process control system. Company engineers believe this feature is the key to protection of the unattended plant.

The so-called "fail-to-safe" design is used on all monitor switches. These switches have a normally open and normally closed contact. When a switch actuates, these contacts simultaneously

reverse. The normally closed contacts are defined as those which are closed during normal, safe plant operation, and are all wired in a series-type circuit to the coil of the monitor relay to provide an energized circuit of the "fail-to-safe" design.

The normally open contacts on each of the monitor switches are wired to a separate indicating circuit breaker. In case of a malfunction, the series circuit opens, causing the monitor relay to drop out. At the same time, the normally open contact on the monitor switch closes, causing the indicating breaker to actuate. There is a few seconds' delay by a time delay relay before power is disrupted. This delay prevents other breakers from actuating due to a secondary abnormal condition caused by the shutdown. When the monitor relay drops out, it opens the compressor motor start-stop circuit to effect the compressor shutdown. Additional contacts on the monitor relay open the circuit to the commercial monitoring service causing a signal to be transmitted, and a pilot light indicates which equipment has been shut down.

Automatic Monitoring of Fireboxes

A review of the major causes of firebox explosions indicates that the following conditions, among others, should be monitored and controlled by automation: flame failure due to liquids or inert gases entering the boiler fuel system, insufficient purge of firebox before lighting the first burner, faulty automatic fuel regulating controls, fuel shutoff valve leakage, unbalanced fuel-air ratio, faulty fuel supply, loss of furnace draft, and faulty pilot ignitors. Add to this the need for control of boiler water pressure, fans, instrument air, gas header pressure, and a multitude of valves, and then it can be readily seen that comprehensive programing for a computer is required.

Pointers for Fire Protection Engineers

The major points to be considered by the fire protection engineer when designing fire protection for an automatically operated plant or process are:

1. A separate monitoring system to operate independently from the process control system.

2. Duplicate monitoring systems and controls in unusual cases.

3. Installation of electronic equipment in atmospheres free of flammable liquid vapors, flammable gases, or combustible or conductive dusts.

4. Possibility of electric power failure to computers and instruments.

5. Since an analog or digital computer cannot think, every possible contingency must be built into the program.

6. Management must be made aware that with a greater investment a small fire can result in a higher dollar loss or cause a plant shutdown interfering with continuous operation.

7. The best available monitoring instruments will save money in the long run.

8. There is a need for more thorough, preventative maintenance programs in order to keep all mechanical and process equipment and instrumentation in top operating conditions. With reduced personnel, housekeeping may well become a problem.

9. Revised or new instructions for fire and emergency use including discussion of procedures, fire and explosion safety rules, training of the few men who are still on duty, recognition of new hazards, notification of fire departments, etc.

Union Carbide Corporation

Control panel for an automated fluorocarbon production unit of the Union Carbide Corporation. Material flow, temperature, and pressure controls are regulated automatically by the control panel. In the event of an abnormal condition in the process system, an alarm signal will show on the panel board. The operator can then make adjustments in the system at the panel board.

10. With greatly reduced working forces, probable elimination of plant fire brigades comprised of general employees. In time of emergency, employees, connected with the operation of the computers or control channels cannot leave their posts. In view of this, a full-time paid fire department will become a necessity in the larger plants.

11. A great number of properly designed fire detectors and extinguishing systems will be required together with fail-safe controls of the processing units.

The fire protection engineer can see that sound recommendations are properly planned while automation is being developed on the drafting board. He must become more highly skilled than ever before to analyze properly these highly complex methods and processes and come up with acceptable solutions.

If fire protection engineers are to maintain their responsibilities for safeguarding life and property, they must face up to these challenges and accept them as opportunities to solve the continuing problem of protecting life and property from fire.

The English Night Club Fire

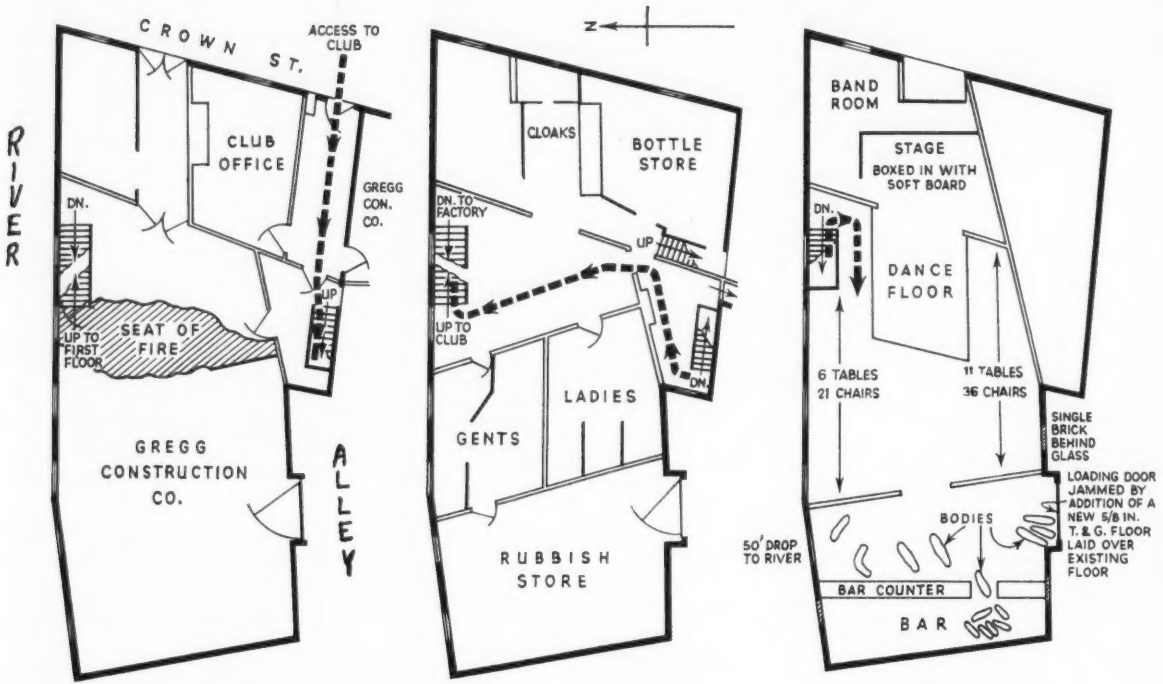
Nineteen of the twenty-four occupants of a third-story private drinking club in Bolton, England, were killed on May 1, 1961, when a fire blocked the only exit. This was the largest number of English civilians killed in a single building fire since World War II. Fire brigade inspectors had sought correction of the exit deficiency in February 1961, and the brigade was working with the Borough Engineer, up to the time of this tragedy, to try to persuade the operator of the club to install an alternate exit.

The "Top Storey Club" was located on the top floor of a 45-foot by 70-foot, 3-story and basement (with subbasement), masonry, wood-joisted building. The building was at 29 Crown Street

This report is based on information furnished by Chief Fire Officer R. C. Bentley, O.B.E., of the County Borough of Bolton Fire Brigade.

Bolton Fire Brigade

Inadequate exits caused 19 of the 24 occupants of the top story of this building to die. Fourteen were trapped and 5 leaped to their deaths in the shallow river outside.



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Plan view of 29 Crown Street, Bolton, England. The dashed line shows the route taken to enter the club.

and was located at the north end of a row of six other buildings of roughly the same construction. It abutted on the other side the small River Croal, which is one of the few masonry-bottom rivers in England. On the river side of the building, the basement and sub-basement were exposed, forming a 50-foot to 60-foot drop from the upper windows to the very shallow river below (see photo). As 29 Crown Street was a longer building than that beside it, a rear portion of the south side adjoined an alley.

To enter the "Top Storey Club," one had to pass from Crown Street through a door to a passageway, through the passageway to a landing at the foot of the stairs, up the stairs to the second floor, and thence up more stairs to the third floor and club (see Diagram).

The building had been leased to a 28-year-old maker of kitchen cabinets. The club was registered with the city on December 19, 1960, by this tenant. The building owner states he was unaware of this change in occupancy. Alterations of the third floor to form a clublike atmosphere included a new tongue and groove floor. The boards laid over the existing floor jammed the loading door to the alley. The two windows overlooking the alley were covered inside with a single course of brick, leaving the exterior unchanged. The rearmost window on the river side was treated likewise. This left as ways out of the club, one window in the Band Room overlooking Crown Street and five windows overlooking the river below, in addition to the single winding exit route by stairs.

On February 1, 1961, the building tenant, now also the club operator, requested the fire brigade to make an inspection. The inspection was made the same day, and the report, issued to the tenant on February 4, said in part:

> "If a fire did occur on the ground or first* floor, when the top room was in full occupancy, there would be every possibility of these people being trapped without any alternative means of escape at their disposal."

On March 24, the club rights were purchased by another man. On April 5, the fire brigade followed up on the original investigation to discover this fact and issued a stronger suggestion to the new club operator:

> "I understand that it is your intention to erect an external fire escape . . . every endeavor should be made to expedite . . . the completion of the escape in order that the very dangerous conditions now existing can be mitigated."

On April 28, the Borough Engineer wrote to the club operator:

> "Before taking further action in this matter, I would like to have your observations as it may well be that . . . you may wish to terminate this unauthorized use."

During this period of warning letters, the owner of the building became aware of the fact that the third floor was being used as a club. He requested that this use of his property be discontinued. In fact, at 10:30 P.M. on the night of May 1, 1961, the building owner had called the operator of the club at the club to warn the proprietor that he must vacate by June.

Thirty-seven minutes later, the fire brigade received a telephone call from a club occupant reporting the fire. On arrival two minutes later, the brigade found the building heavily involved on the lower two floors. Eight persons had jumped to the river or river bank. Two had escaped by running down the smoky, hot stairway. As fire fighters

Plan view of 29 Crown Street, Bolton, England. The dashed line shows the route taken to enter the club.

*In England the first floor is the one immediately above the ground floor.

fought their way in, they found 14 bodies near the club bar. One was the owner of the club.

Three of the 14 victims found near the bar died trying to force the blocked loading door open. Careful examination of the door indicated that it could have been lifted off its hinges. As a truck was parked outside in the alley, only a 15-foot drop would have been required for escape.

Five of the eight who jumped died of shock or internal injuries, even though the river was at an abnormal depth — four feet — due to heavy rains. One woman was saved when her dress caught on an iron angle bar sticking out on the river side of the building.

Due to the burn pattern on the floor, the cause of the fire in the ground-floor woodworking shop was thought to have involved flammable liquids. Highly flammable thinner was used in the wood finishing operation, according to reports after the fire, but the details of ignition and spread remain a suspicious mystery.

Fire Exposure of People in Shelters

By A. Broido and A. W. McMasters

Pacific Southwest Forest and Range Experiment Station
U. S. Department of Agriculture, Forest Service

To study fire exposure to people in civil defense shelters, measurements of temperatures and oxygen and carbon monoxide concentrations were made in simulated shelter vents on a series of planned fires ranging in size from a single schoolroom to 900 tons of fuel spread over 9 acres. The results demonstrate that extreme carbon monoxide concentrations may be expected in large scale fires burning out of doors. However, they indicate that closure of the vent system to protect against fire effects will seldom, if ever, be necessary for more than an hour or two if the vents are located so that they will not be covered by rubble. If the vents are covered by rubble, closure for a period of days may be required.

Recommended civil defense shelters range from thick reinforced-concrete blast shelters down to makeshift fallout shelters in individual residences.[1] Nuclear detonations are expected to produce large area fires,[2] and many situations may be expected in which certain shelters will survive the effects of the fire, while the shelter occupants will not survive unless precautions are taken

The work described in this paper was sponsored by the Office of Civil and Defense Mobilization and was in part presented at Palo Alto, California, in April 1960 to the Western States Section of the Combustion Institute. More detailed description of the fires is included in Technical Paper No. 50, the Pacific Southwest Forest and Range Experiment Station, entitled "Effects of Mass Fires on Personnel in Shelters."

For superior number references see page 140.

Figure 1. View of first Richmond test fire 33 minutes after ignition (described on page 133).

to protect them against toxic gases and heat. The need for these precautions may continue for hours in situations where the fire smolders around or over such shelters.

Need for Fire Exposure Data

Human tolerances of the various effects which may cause deaths in fire-resistive shelters have been determined in studies of fire fighting, submarine, and manned-rocket operations.[3, 4, 5, 6, 7] Not so well established is the nature of the life hazard to be expected in shelters located in areas where there are severe ground-level fire exposures. Although a number of designs and types of shelters have been tested for blast and radiological protection, the fuel-free terrain in which these tests have taken place have offered no opportunity to study the effects of mass fires over and around the shelters.

Wartime Experience Not Definitive

In the mass fires resulting from air attack during World War II, many people lost their lives in shelters in fire areas.[8, 9] The greatest number of deaths occurred in basements or makeshift shelters. In many cases, positions of the corpses indicated that death came peacefully and unexpectedly. A frequent assumption is that death was due to carbon monoxide poisoning. However, cause of death has also been attributed to such effects as (a) asphyxiation resulting from the depletion of oxygen either through conversion to carbon dioxide or by suction created within the burning area, (b) the effects of inhaling hot blasts of air, and (c) roasting of the shelter occupants as a result of heat transfer into the shelter. The confusion which still exists concerning the sources of hazard is exemplified by the apparent inconsistency between reports of past experiences and present practice in Germany. Although most reports describing the great German fires of World War II list carbon monoxide as the principal cause of deaths, current shelter plans of the West German Government ignore carbon monoxide and call for sand filters to remove heat from the ventilation air.[10]

Just as the evidence obtained in wartime fires has proved to be too conflicting for unequivocal interpretation, so have data from past experimental fires led to conflicting interpretations. Thus, evidence for carbon monoxide poisoning as a possible explanation comes from a series of "burn-out" tests conducted in an experimental dwelling-room.[11] In these tests the production of toxic concentrations varied considerably, depending on the supply of air to the fire and its path through the room, but a maximum concentration of 13.8 per cent carbon monoxide was reached between the sixth and eleventh minutes in one of the fires. On large-scale outdoor fires,[12] on the other hand, attempts to measure carbon monoxide concentrations sufficiently high to produce death have not been successful.

Limitations of This Study

The study reported here was undertaken in an attempt to resolve some of the existing conflicts. The scope of the study was dictated by limited manpower and a very limited budget. Funds allocated for the project did not permit construction of full-scale shelters or large-scale fires exclusively for project use. Practically all field testing was accomplished with simulated shelter vents on fires planned for other purposes.

Test Fires for This Study

The fires included a series of tests in structures being demolished in several California cities — tests which were undertaken primarily to check out and calibrate instruments impro-

vised from a variety of surplus military parts, but which served also to provide much interesting data. Five such fires were instrumented: two in one classroom of the Robert Louis Stevenson Junior High School, being demolished in Los Angeles,* two in buildings which had been turned over to the Richmond Fire Department for destruction in connection with a redevelopment project, and one in an El Cerrito municipal building which was being razed.

In addition, the East Bay Municipal Utility District made a large-scale burn possible by requesting aid from the Experiment Station in clearing about 100 acres of wooded land for a reservoir site near Orinda, California. To clear the site, trees and brush were bulldozed into windrows for subsequent drying and burning. The fire instrumented for these studies consisted of 11 windrows covering a total of about 9 acres, with an estimated fuel loading of 900 tons oven-dry weight.

Finally, an invitation to participate in a U. S. Navy shelter design study permitted a proof test of previous assumptions and conclusions in a large area burn involving about 300 tons of fuel stacked in a 4-acre plot around a full-scale shelter at Camp Parks, Pleasanton, California.

Air Sampling

Most of the measurements made during the course of this project can be grouped into two categories: temperature measurements and gas concentration measurements. Vacuum pumps (i.e., vacuum cleaners) were used to draw air first through vents instrumented for temperature measurements, then through a cooling bath to cool the gases before their entry into appropriate gas concentration measuring devices.

On the basis of discussions with engineering personnel of the U. S. Office of Civil and Defense Mobilization, simulated intake vents were made of 4-inch steel pipe 3 feet long, designed to extend 2 feet above grade, and equipped with a protective cap on the inlet end. For the preliminary calibration tests at the Stevenson Junior High School, the cap was removed and replaced by a 10-foot section of 4-inch inside-diameter galvanized sheet steel pipe. Individual tubes were run through the pipe to measurement locations at heights of 2, 6, and 10 feet above the floor. For all of the other experiments, air was drawn directly into the vent itself.

In addition to these stationary vents, a portable probe was used in several experiments to check temperatures and gas concentrations which could be expected if a vent were buried under the rubble smoldering after the flames had died down.

Temperature Measurements

Through simple computation it may be shown that heat transfer through walls of a shelter 3 feet underground may usually be ignored as a mechanism for producing casualties to personnel therein. Therefore the only heat transfer mechanisms considered were the conduction of heat into the shelter through the walls of the shelter vents and the intake of hot gases through these vents. For measurements of pipe wall temperatures, chromel-alumel thermocouples were chosen because of their ability to measure temperatures up to 2,500°F. To keep the instrumentation simple, it was decided to mount identical thermocouples in the gas streams flowing

*This school was offered by the Los Angeles Board of Education to the Los Angeles Fire Department for the purpose of conducting fire tests to answer questions raised as a result of the tragic fire at the Our Lady of the Angels School, Chicago, Illinois, on December 1, 1958. The official report of those tests, entited "Operation School Burning," was published in 1959 by the NFPA.

through the vents and later to correct the thermocouple readings to true gas temperatures.* The corrections to true gas temperatures were made by considering the vent-thermocouple system as a large, shielded, aspirated thermocouple and using the procedure suggested by Fishenden and Saunders.[13]

Except for the first two calibration runs, temperature measurements were made just beneath the vent cap, and at distances of 1, 2, and 3 feet below the cap. At each location, thermocouples were installed in the gas stream and in the pipe wall. Several vents had thermocouples installed at more than one point at the same height to investigate radial asymmetry of the temperature distribution.

Gas Concentration Measurements

Because most fires were to be limited to wood fuels, it was decided to limit continuous gas concentration measurements to oxygen and carbon monoxide. Continuous oxygen measurement was made with a Thermco Instrument Corporation Model P-9 Oxygen Analyzer modified for connection to recording equipment. This instrument utilizes the paramagnetic properties of oxygen for the analyses.

Continuous carbon monoxide measurements were made with instruments developed from surplus detectors which had previously been used as warning devices in aircraft. These detectors split the flow of a gas sample through two cells connected by a thermopile. One cell contains activated hopcalite which catalyzes the oxidation of carbon monoxide. The resulting temperature difference between the two cells is a function of the carbon monoxide concentration in the air being sampled.

Figure 2. El Cerrito municipal building shortly after ignition (described on page 133).

In addition to the continuous gas analysis instruments, a gas sampling device was constructed which would handle six sampling bottles in sequence. Upon signal, the valves of one bottle open, a vacuum pump draws a gas sample into the bottle, the valves are automatically closed, and the unit positions itself to take the next sample. The bottled samples were analyzed using a Beckman IR-4 Infrared Spectrophotometer with a 10-meter-path length gas cell.†

Calibration Tests

The two fires in the schoolroom were ignited in scrap lumber and permitted to burn until, in the opinion of the Los Angeles Fire Department, they were

*Since the actual temperatures experienced in a shelter which draws hot air through a vent would depend greatly upon the heat capacity of the shelter contents, no attempt was made to compute shelter temperatures which might result from the entering air. The importance of such heating is seen by comparison with the heat generated by shelter occupants. For example, in a five-man shelter drawing the recommended minimum ventilation rate of 5 cubic feet per minute per person, the heat output of the occupants would be 2,000 Btu per hour while ventilation air entering at a temperature of only 1,000°F would carry into the shelter a net heat of 28,000 Btu per hr.

†The analyses were carried out by Dr. Milton Feldstein, Laboratory Director, San Francisco Bay Area Air Pollution Control District.

endangering the floor above. In each case they were extinguished before the fuel at the base of the vent (located in the center of the room) could be burned. Under these circumstances, measured temperatures were much higher at the ceiling than they were at the lower air intakes — exceeding 1,800°F 7 minutes after the start of one of the fires. At the 2-foot intake on this same fire, the carbon monoxide concentrations reached lethal levels within 5 minutes (concentrations over 1 per cent cause immediate unconsciousness and death within 3 minutes[5]) and by the time extinguishment was started (at 12 minutes) the oxygen concentration had dropped to a dangerous level (10 per cent).

The first Richmond test (Figure 1) was conducted in a 2-story four-apartment building, measuring 50 feet by 28 feet, with stucco-covered exterior, sheetrock-covered interior, oak floors, and scrap lumber to simulate furnishings. The intake vent was located in the center of a 16-foot by 11-foot living room on the first floor. The building was ignited and permitted to burn to the ground.

The hottest measured temperatures occurred after the second story collapsed around the vent (at about 40 minutes). Gas temperatures exceeding 2,500°F were found for short periods; and under some circumstances, relatively cool air entering the vent was heated to high temperatures as a result of heating of the vent walls by radiation from the fire. (Heat transfer from the vent walls to the air stream is by convection to the air and by radiation to the entrained smoke particles.)

Figure 3. Rubble left after El Cerrito test.

Lethal concentrations of carbon monoxide were reached as the apartment building began to collapse, the highest concentrations (greater than 3 per cent) occurring as the roaring fire began to die down and the building was reduced to a pile of rubble.

The second Richmond test consisted of two single-story wooden houses, one measuring 50 feet by 22 feet and the other 24 feet by 18 feet, 7 feet apart at their nearest corners. One vent was located in the living room of one house. The other was located outside between the two houses. During this fire, measured gas temperatures again exceeded 2,500°F, carbon monoxide concentrations exceeded 1 per cent, and oxygen concentrations dropped below 5 per cent for a brief period.

Razing of an old municipal building as a fire training exercise for the El Cerrito Fire Department provided an opportunity to investigate lingering effects in rubble. The building (Figure 2) had been the old firehouse, jail, and police station. The jail section had thick concrete walls, and the remainder of the building had stucco- and brick-covered walls.

After all unstable wall remnants had collapsed and the general area had cooled down sufficiently, probing of the rubble piles was begun. Temperatures, carbon monoxide concentrations, and oxygen concentrations were measured at various locations within the rubble (Figure 3) at intervals starting about 4 hours after ignition and ending about

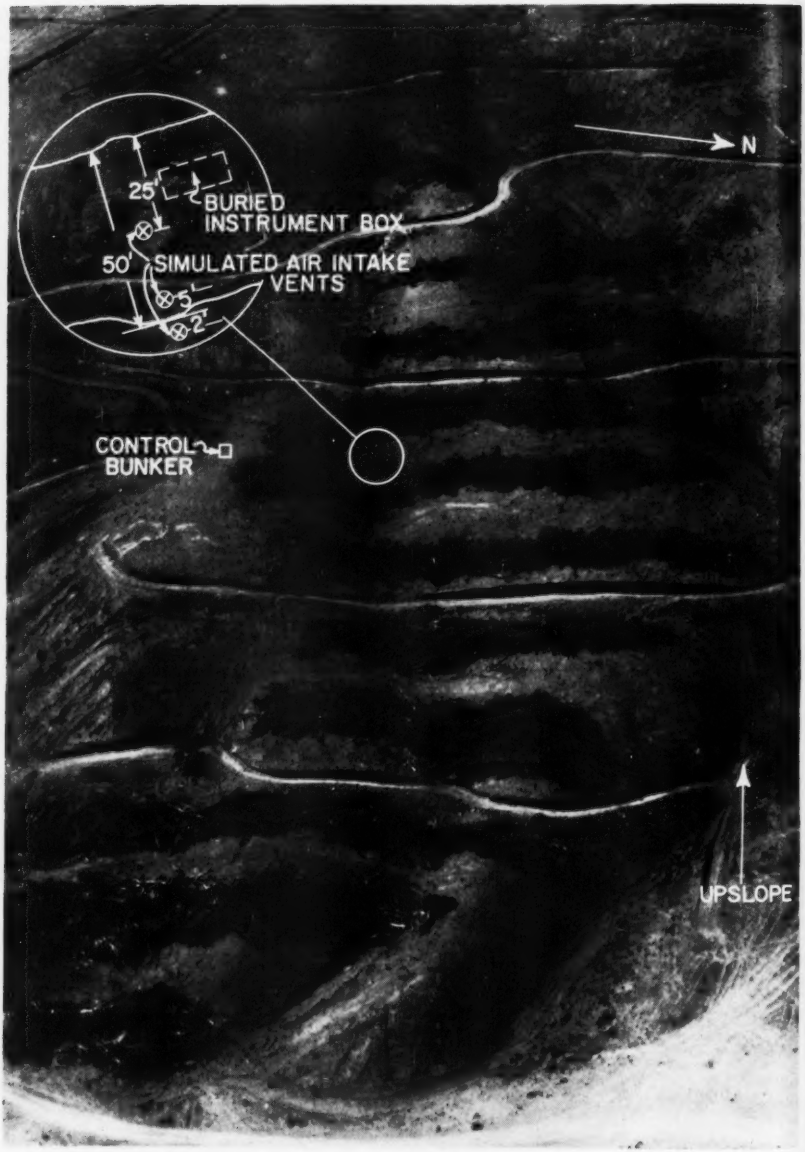

Figure 4. Aerial view of the Briones burn area.

Figure 5. Closeup of fuel in Briones burn area.

22 hours after ignition, when earth-moving equipment was brought in to complete demolition. Nearly 24 hours after the start of the fire, temperatures of almost 1,900°F and carbon monoxide concentrations greater than 1 per cent could still be found.

Briones Burn

The fuel distribution for the 9-acre Briones burn is shown in Figure 4 and a closeup of the fuel in Figure 5. For this burn, three simulated shelter air intakes were installed (Figure 6): vent A inside the fifth windrow, vent B just outside this windrow, and vent C midway between the fourth and fifth windrows. The gases drawn into these vents were conducted to a buried instrument box containing the gas sampling mechanism and gas detectors. The instruments in the box were remotely controlled from a bunker which also contained all recorders. The placement of the intake vents was designed to take advantage of uphill drafts anticipated as a result of the fire. Instead, westerly winds, with speeds ranging from 10 to 14 miles per hour and gusts up to 20 miles per hour, blew the flames downslope (Figure 7).

As might be expected, the highest temperatures were obtained at vent A, much cooler temperatures at vent B, and coolest temperatures at vent C. However, the wall temperatures at 1 foot below ground level were approximately the same for all three vents.

At vent A, the oxygen concentration dropped to practically zero (less than 2 per cent) at about 8 minutes. The carbon monoxide reading at this vent rapidly went off scale (greater than 2 per cent) and the detector burned out at 6 minutes. Spectral analysis of the gas bottle samples showed that, even in a fast-burning, rubble-free fire such as this, serious carbon monoxide and carbon dioxide effects can be found as late as 1½ hours after ignition (e.g., the sample taken 87 minutes after start contained 0.16 per cent CO and 5.8 per cent CO_2).

At vent B, carbon monoxide concentrations gave off-scale readings within 5 minutes of ignition time although oxygen concentrations never fell much below 14 per cent. The carbon monoxide concentration dropped below 0.1 per cent in 10 minutes but still exceeded 0.02 per cent (sufficient to cause mild headaches) three hours later. The gas concentrations at vent C never reached toxic levels, but carbon monoxide

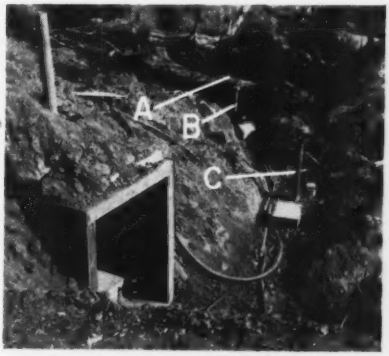

Figure 6. View before backfill showing placement of vents for Briones burn.

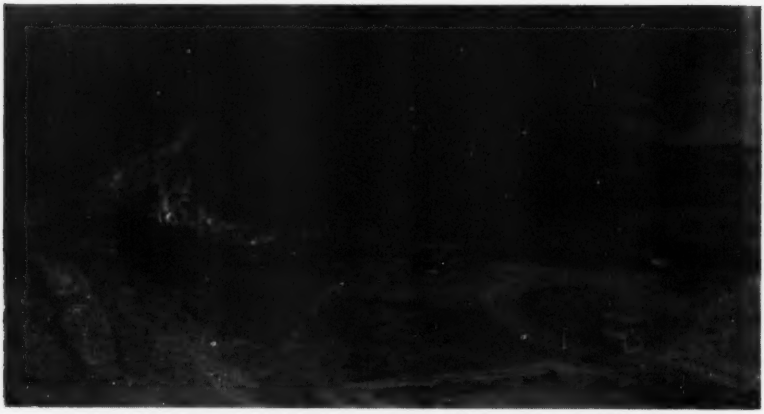

Figure 7. The Briones burn 10 minutes after ignition.

concentrations of about 0.02 per cent were found for several hours.

Camp Parks Burn

To permit experimental verification of the conclusions of a shelter design study, the U. S. Naval Radiological Defense Laboratory (NRDL) constructed a 100-man prototype underground shelter at Camp Parks.[14] Since the shelter design included a "fire storm" protection capability, a cooperative program was undertaken. The very limited budgets of the two participating groups precluded the installation of extensive instrumentation. However, the availability of a considerable quantity of scrap lumber, some manpower to relocate the fuel and assist in the installation of instrumentation, and a competent fire department to provide necessary protection permitted the conduct of a minimum experiment.

Lumber was distributed to simulate fuel distribution in a densely populated area (about 30 per cent density) of single-story dwellings. The fuel was placed in piles measuring 20 feet by 15 feet, 7 feet high, and spaced 12 feet apart along three concentric rectangles with 50-foot spacing between rectangles (Figure 8). The three piles nearest the shelter entrance were increased to a height of 9 feet by including randomly throughout each pile an additional 2 feet of noncombustible rubble — pieces of concrete, brick, and gypsum board.

Limited instrumentation was installed in the entranceway and main room of the shelter. However, the principal measurements were made from three simulated air intake vents located near the shelter entrance — vent A in a rubble-free wood pile, vent C in a pile containing rubble, and vent B midway between the other two.

To insure nearly simultaneous ignition of all the fuel, about 2,000 gallons of used crankcase oil were sprayed on the fuel piles, and they were ignited by a series of six ignition circuits — two in each of the concentric rectangles. The successive circuits were closed at 30-second intervals and the fire grew rapidly. Less than 4 minutes after ignition of the first rectangle, strong indrafts from all sides were blowing the flames toward the center of the fire, with flames 50 feet high visible through the dense black smoke. By 6 minutes, the

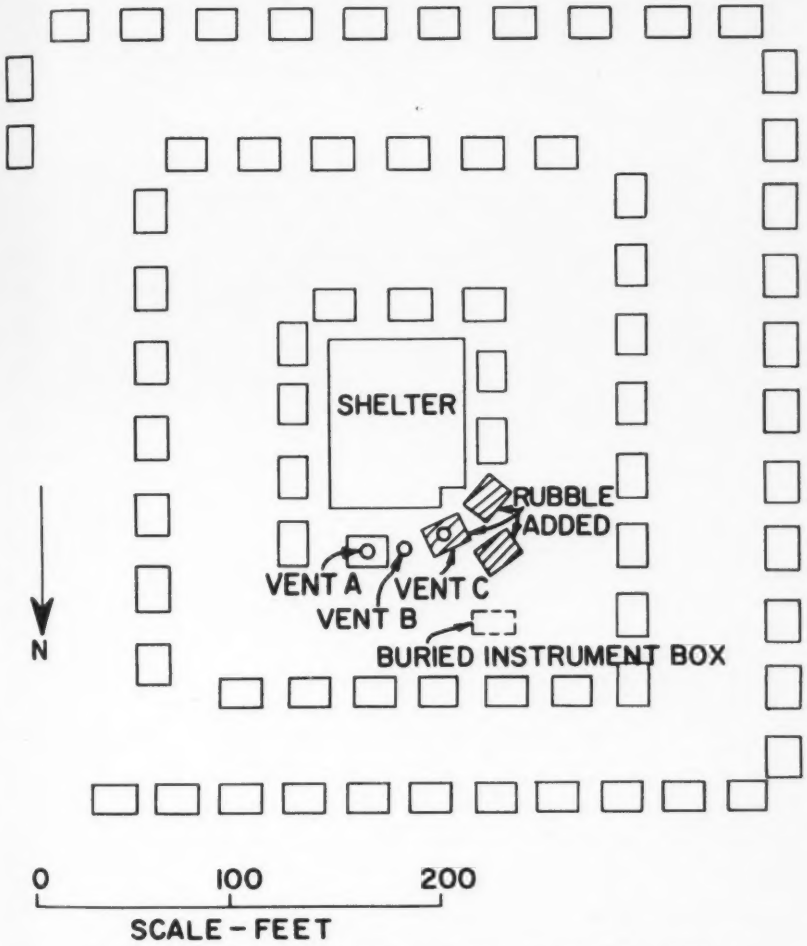

Figure 8. Diagram of fuel distribution about 100-man shelter at Camp Parks.

smoke began to clear, and, within another minute or two, there was a noticeable reduction in fire intensity. By 10 minutes after the first ignition, the merging flames had separated into a group of individually burning fires (Figure 9). Within another 10 minutes, some of the piles had been reduced to a bed of glowing coals and stopped flaming. An hour after the start, one could enter the fire area if he avoided still burning or smoldering fuels.

Temperatures in vent A rose rapidly, and all of the above-grade thermocouples burned out after recording temperatures as high as 2,600°F within the first 10 minutes. After an initial rise, gas temperatures of vent C, in the pile containing rubble, fluctuated between 800°F

Figure 9. Camp Parks from helicopter. View from southeast, 15 minutes after start. Individual piles burning independently.

and 1,200°F for about an hour, fell gradually to 600°F at two hours, then rose smoothly back to 1,200°F during the next two hours, until, about 4 hours after ignition, the rubble pile began to collapse about the vent entrance. At this time temperatures again rose rapidly (reaching approximately 1,700°F at times) and remained high and irregular for about two more hours until the rubble settled to its final depth — below the vent entrance.

The rubble remained hot for a long time after measurements were terminated. In fact, five days later, when the area was being cleared, freshly exposed fuel in the bulldozed rubble piles again burst into flames.

Relatively low temperatures (less than 660°F) were obtained by thermocouples not actually in one of the fuel piles. Thermocouples mounted on the inside of the uninsulated portion of the shelter entrance recorded 200° to 300°F for a short while, but most of the thermocouples in the entranceway and at other locations throughout the shelter, failed to show any significant increase in temperatures as a result of the fire.

The oxygen concentration at vent B did not drop significantly at any time. At vent C, the oxygen concentration began to decrease almost immediately (about a minute after ignition of the inner rectangle) and dropped almost to zero (less than 2 per cent). The oxygen concentration remained at a very low level until the vent began to emerge from the rubble pile as the pile collapsed around it some 3 to 4 hours after the start of the fire.

The carbon monoxide unit connected to vent A indicated an off-scale reading (greater than 2 per cent) about 1½ minutes after ignition of the inner "ring," the concentration dropping rapidly as the wood pile was consumed. The carbon monoxide analyzer attached to vent C indicated no reading until about 4 minutes after ignition of the first "ring"; then it rapidly shot off scale. Repeated attempts to obtain an on-scale reading soon filled the instrument with a large volume of liquid wood distillation products. Gas sampling showed concentrations as high as 7 per cent CO and 8 per cent CO_2 remaining for 3 or 4 hours — dropping to

safe levels only after the rubble pile settled below the level of the vent entrance. The highest value of carbon monoxide observed in vent B was 0.08 per cent about 6 minutes after ignition of the first rectangle. The carbon monoxide analyzer in the shelter entrance showed no detectable concentration (less than 0.02 per cent) of carbon monoxide entering the shelter. Analysis of the gases in the main shelter room showed the highest carbon monoxide concentration observed to be only 0.001 per cent before opening the shelter door. After the shelter was opened and several groups of observers had passed through, the concentration rose to 0.02 per cent.

Conclusions

The conclusions listed below should be tempered by the limitations imposed by the restricted scope of this project. Thus, it is important to remember that the largest burn conducted in this series was much smaller than the minimum necessary to fall within the definition of a mass fire.[15] Also, since a large-scale fire is a highly variable and complex phenomenon, it is difficult to decide how "typical" these fires might be, that is, how often events observed during these fires would be found in other "similar" fires. As a matter of fact, it is necessary to use considerable caution in extrapolating the measurements made during these fires to other locations within the same fires. However, if a dangerous situation was encountered even once during these experiments, it is safe to assume that it will be encountered again in some future fire and that a feasible attempt to mitigate the consequences should be encouraged.

With the above precautions in mind, the major conclusions which appear from examination of the data obtained during this project may be listed as follows:

1. Extreme carbon monoxide concentrations are to be expected in large-scale fires burning out of doors.

2. Although oxygen depletion and high carbon dioxide concentrations may also occur, their effects will be of consequence only if some steps are taken to eliminate the carbon monoxide hazard.

3. Air temperatures in the fire may be expected to exceed 2,000°F, and conventional ventilation systems, if operated during the fire, may be expected to carry into the shelter much more heat than is generated by the shelter occupants.

4. If ventilation systems are to be operated during a fire, shielding of the intake vents from radiant heat should be considered since, under certain circumstances, cool intake gases may actually be heated in passing through the vents.

5. Smoldering rubble will maintain higher temperatures and toxic gas concentrations for longer periods than the more impressive flaming phase of a large fire. In fact, it appears that if shelter vents are located so that they will not be covered by rubble, closure for more than an hour or two will seldom, if ever, be necessary. Conversely, if the vents are covered by rubble, closure for a period of days may be required.

6. Placing a home shelter vent just outside of a residence may be of little value since high concentrations of toxic gases will sometimes be found in these locations.

7. Although fatal concentrations of carbon monoxide were found 5 feet from the fire — and concentrations sufficiently high to cause headaches were found 25 feet from the nearest fuel — during the Briones burn, no significant concentrations were found outside of the burning piles during the Camp Parks burn. What would occur in a much larger fire is impossible to predict, but a good rule to follow would seem to be: where pos-

sible, locate a shelter in a cleared area sufficiently large that the shelter will not be covered with rubble, and within that area locate the vent as far as possible from combustible materials.

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Water on Oil Fires

By Oliver W. Johnson

Fire Protection Engineering Consultant

Once the statement was often heard, "Never put water on an oil fire." This statement is now known to be poor advice. However, as compared to the use of water on fires in ordinary combustible materials there are differences in the way it may be used successfully and limitations in things it can accomplish.

Heat Release vs. Cooling

Water is pre-eminently a cooling agent. E. A. Hibbitt, Senior Fire Prevention Officer, Fire Brigade, Manchester, England, states, "Theoretically the ideal way to extinguish a fire with water is to use exactly the right quantity, which, in vaporizing, will absorb sufficient Btu to cool the burning substance below its ignition temperature. If this could be achieved, the danger of damage by water to valuable commodities untouched by the fire would be eliminated." Mr. Hibbitt then goes on to show that the rate of heat release is likely to exceed by far the rate of heat absorption of all the water that it will be practical to apply.

Much the same idea is expressed by S. D. Klinger, Beloit, Wisconsin. "As a corollary to the principle of finding the fire and hitting it with water, it might be added that even though you are hitting the fire, it cannot be extinguished unless the cooling effect of the water exceeds the rate at which the fire is producing heat."

The underlying idea in both of these quotations is to relate the cooling effect of water to the heat release in the fire. It will be well to investigate this relationship in more detail.

Cooling Effects of Water

Since water used for cooling must itself be heated, the range of temperature over which it is heated is a measure of the cooling effect. If some of the water is converted to steam, an additional amount of heat is absorbed from the fire. Table 1 shows the amount of heat absorbed by water that is heated from 62° to 212°F and when it is converted to steam.

The maximum possible cooling effect of water applied in fire fighting would be achieved if all of the water were converted to steam, and none of it ran off. Many factors combine to make it a practical impossibility to achieve this ideal efficiency.

Heat Release from a Fire

In assessing the value of water in absorbing the heat of a fire, it is necessary to know how fast the heat is being released. Although this subject has not been thoroughly investigated, the *NFPA Handbook of Fire Protection* suggests an interesting approach to the problem.* Time-temperature plots are given for the actual burning of six different structures, including three office occupancies, a record storage vault, a

This paper is based on a talk given by Mr. Johnson at the Oil Fire Control School, Bakersfield, California, March 1961.

*"Fire Loads," pp. 521–524, Eleventh Edition of *NFPA Handbook of Fire Protection*.

Table 1

Water as a Cooling Agent

	Total Heat Absorption	
	Btu per Pound	Btu per Gallon
Heat from 62°F to 212°F	150	1,250
Boil at 212°F	970	8,080
Total	1,120	9,330

Table 2

Rate of Fuel Consumption and Heat Release

	Pounds per Minute per Square Foot	Btu per Minute per Square Foot
Structural Fire		
Average	0.4	3,000
Estimated Maximum	1.6	12,000
Furnace, Coal Fired	0.9	12,000
Oil Fire in Open Tank	1.0 (⅛ gallon)	14,000

household furniture warehouse, and a dwelling. The total "fire load" or amount of combustible material per square foot is given in each case. By noting the period of time during which combustion was proceeding at the most rapid rate, as indicated by the temperature curve, the author attempted to make an estimate of the rate at which the fuel substance was being consumed, and hence, also, the rate of heat release. From the data available it was estimated that the rate of fuel consumption in all six fires ranged between 0.30 and 0.46 pounds per minute per square foot, amounting roughly to a heat release of 3,000 Btu per minute per square foot of building area. This average prevailed over periods of 30 to 60 minutes, although the peak rate must have been several times higher.

Another basis for estimating the rate of burning of a solid fuel is available in the test of the furnaces of steam boilers. Tabulated results of tests of some 30 different boilers gave as the lowest rate of heat release 2,000 Btu per minute per square foot of grate area, and the highest, 20,000 Btu per minute per square foot, with the great majority approximately 12,000 Btu per minute per square foot. Although this is four times the average figure calculated from the previously mentioned tests on actual buildings, this ratio seems reasonable in view of the ample and controlled air supply in a boiler furnace. It probably closely approximates the peak rate of heat release for uncontrolled fires in buildings.

For oil fires, also, the rate of heat release can be estimated with reasonable accuracy. Over the years it has been observed that in fires in open top oil tanks the rate of lowering of the liquid surface does not differ widely in spite of variations in the type of oil, wind, the distance from the tank rim to the oil surface, and the tank diameter. In other words, the rate of burning per square foot has been found to be relatively constant. For gasoline and other volatile petroleum oils, a good average figure for the burning rate is 12 inches per hour. In terms more convenient for the present purpose, this is 28.8 cubic inches per minute per square foot or ⅛ gallon per minute per square

foot. Burning an average oil at this rate will yield about 14,000 Btu per minute per square foot of fire area.

Table 2 contains author's estimates for the average heat release data for structural fires, coal furnace fires, and open tank oil fires.

"Total Heat Absorption" Fallacy

If extinguishment were, in fact, to depend on removal of all of the heat of combustion by the fire fighting streams which are applied, the quantities of water which would be needed can easily be computed as shown in Table 3. Even casual inspection will show that these figures are unrealistically high. To extinguish a "maximum" fire involving a 50-foot by 100-foot building would on this basis require over 6,350 gallons per minute, assuming that there was no runoff and that all of the water was converted to steam. Since fires are consistently extinguished with much smaller water rates, even with large runoffs, there is no substantiation for the "total heat absorption" theory of extinguishment and it must be abandoned.

Extinguishment by Cooling the Fuel

As stated in the *NFPA Handbook of Fire Protection*, the actual combustion of most substances takes place only after the solid or liquid fuel has been vaporized or decomposed by heat to produce a gas. Therefore, anything that interferes with the transfer of heat to the as yet unvaporized fuel will interfere with the process of burning. When water is applied to a fire in wood or other similar combustible material, its principal effect is to cool the unburned wood, stop the evolution of vapor from it, and thus starve the flame which feeds upon this vapor.

Certain petroleum products behave in a manner very similar to wood. Heavy fuel oil, lubricating oil, and asphalt do not produce vapors in significant amounts until heated to a high temperature. But if a fire is once started by combustion of some other material close by, these oils will give off vapor enough to burn. Once vaporization is started, the supply of vapor is maintained because the flame continues to supply sufficient heat to the oil surface. If no preventive steps are taken, the fire will continue until the oil is consumed. However, if water — preferably in the form of a light spray — is applied to the surface, the oil on the surface will be cooled, with the result that the release of vapor to feed the flame will cease, and the fire will go out.

Thus, for fires in certain kinds of oil (those with high flash points), extinguishment is accomplished by water in much the same way as in the case of fires in wood or other ordinary combustibles.

Table 3

Water Required to Absorb Total Heat Released

	Total Heat Release Btu per Minute per Square Foot	Water in Gpm per Square Foot	
		Heat from 62°F to 212°F	Heat from 62°F to Boiling
Structural Fire			
Average	3,000	2.4	0.32
Estimated Maximum	12,000	9.6	1.27
Furnace, Coal Fired	12,000	9.6	1.27
Oil Fire in Open Tank	14,000	11.2	1.50

Table 4

Water Required to Absorb Heat from Exposed Surfaces

Total Heat to be Absorbed Btu per Minute per Square Foot of Surface	Gpm per Square Foot of Surface Theoretical: Heat From 62°F to 212°F	Theoretical: Boil at 212°F	Practical: Rate
Oil Surface (100 Btu)	0.08	0.012	0.10
Tank Shell (333 Btu)	0.26	0.04	0.20

The theoretical quantity of water required to effect extinguishment of fires in heavy oil by interrupting the fuel supply can be estimated from the data in Tables 1 and 2. Table 2 states that 14,000 Btu per minute per square foot were produced by burning ⅛ gallon per minute per square foot. Since the latent heat of vaporization of oil is around 800 Btu per gallon, it would take only about ⅛ of 800, or 100 Btu per minute per square foot of fire area to produce the vapor to achieve this burning rate. This is a very small fraction of the total heat release of 14,000 Btu per minute per square foot, and, thus, if a way could be found to intercept this small amount of heat so that it could not reach the flammable liquid surface, vaporization would theoretically cease, and the fire would go out.

If the burning oil has a boiling point above 212°F, any water reaching the oil surface will boil and will thereby exert its maximum possible cooling effect. If it is assumed that the water is heated to 212°F while passing through the flame, all the water droplets that do reach the oil surface would still be capable of absorbing about 8,000 Btu per gallon of water. Thus only 100/8,000 or 1/80 of a gallon of water per minute per square foot of fuel surface (0.012 gpm per square foot) need actually reach the surface to accomplish the desired cooling and thereby extinguish the fire. Naturally, only part of the water directed on the fire will reach the oil surface and the total quantity used will therefore be considerably greater than theoretical, but the quantity is still wholly practical and far below that calculated under the "total heat absorption" theory.

Water on Low Flash Point Products

If water is applied to a fire involving a flammable liquid that gives off sufficient vapors to burn when the liquid is at ordinary temperatures (flash points below 70°F), any water which reaches the surface of the burning liquid will not boil and will probably sink to the bottom without being greatly heated. The principal cooling effect of the water application will take place within the flame itself where a certain amount of the water will inevitably vaporize and remove heat. In such instances, the heat is being removed from the flame, not from the fuel, and consequently, extinguishment is being attempted by the "total heat absorption" method and thus vastly greater quantities of water are required.

A break in a gasoline pipe, resulting in a spill of 10 gallons per minute, can be used to illustrate some of the characteristics of a spill fire involving a low flash point petroleum product. Assuming that ignition takes place immediately, the fire area will be small at first, but will speedily enlarge until the area is sufficient to permit consumption of all of the fuel just as fast as it escapes. From the figures previously given (see Heat Release from a Fire, page 141),

the burning rate is ⅛ gallon per minute per square foot or 8 square feet for each gallon per minute. A leak of 10 gallons per minute will, therefore, produce a fire area of at least 80 square feet. This is equivalent to an area 4 feet wide by 20 feet long, and if the terrain is such that the flow will tend to follow this pattern, the fire will approach this area and then cease to expand. It will continue to burn, occupying about this same area, as long as the rate of fuel supply is maintained. It can grow no larger because the fuel is being burned as fast as supplied; it will not grow smaller because just this much fire area is required for air access, heat transfer, and vaporization to balance the feed rate.

If water is applied to the gasoline spill fire, some of the small drops will be evaporated to absorb heat from the flame, thus slightly decreasing the rate of heat transfer to the spill surface. In addition, the water which reaches the surface will slightly cool it, thereby decreasing the rate of vapor release. Both effects will tend to decrease the burning rate per square foot, and, since the fire is being fed at a constant rate, the fire area will expand (if the terrain permits) to make up for the decreased burning rate. In other words, the fire will spread. If, of course, the fire is so restrained that it cannot spread, the level will rise until the enclosing walls cease to be able to contain it.

Most of the water used on such a gasoline fire will end up beneath the fuel, floating it so as to raise the level, and thus the water will tend to make the gasoline overflow any retaining walls.

From this example it can be seen that, except under highly unusual circumstances, water cannot extinguish a fire involving low flash point petroleum products such as gasoline.

Water on Exposed Containers

Water is an effective cooling agent for steel surfaces exposed by fire, particularly when the temperature of the exposed steel is above the boiling point of water. A heat transfer rate of 20,000 Btu per hour per square foot is often mentioned as a peak rate for heat transfer to fire-exposed steel, such as the shell of a tank. This is 333 Btu per minute. If the tank surface were above 212°F, so that all of the water which reached it boiled, this amount of heat could be absorbed, and the steel could be protected from overheating (i.e., kept from going much above 212°F) if only about 0.04 gallons per minute reached the surface. Since, in practice, only part of the water actually reaches the surface to do this maximum amount of cooling, an application rate of 0.2 gallons per minute per square foot is frequently recommended.

Many petroleum products including gasoline, kerosene, and stove oils boil below 212°F. That part of the shell of a tank containing one of these low boiling products which is below the liquid level will therefore be kept cool by the liquid inside. Even though the liquid is boiling, the steel which it contacts cannot get very hot, and water applied to such a surface cannot absorb the maximum amount of heat.

As far as petroleum product tanks are concerned, it is a safe rule to say that the tanks will not need cooling unless flames actually touch them. Radiant heat will not damage them. The parts of the tanks which are invisible because they are enveloped in the flame are the parts which need the protection; steel which can be seen is unlikely to be endangered.

Oil vs. Ordinary Combustibles

The preceding discussion has demonstrated that as far as extinguishment

by water is concerned, fires in high flash point petroleum oils are basically the same as fires in ordinary combustible materials. There are, however, three important differences:

1. Oil fires usually occur in the open where the rate of heat release may be higher than in a building where access of air is restricted.

2. Oil can flow from one place to another.

3. Since oil will float on water, the act of applying water in an attempt to control the fire may introduce complications.

Mechanical Effects of Water

Since oil floats on water, flooding a fire area may cause burning oil to flow to an area where it could do a great deal more damage, or, on the other hand, the burning oil may be diverted into an area where it could burn without doing any damage at all. Where it is desired to divert burning oil as indicated, it may be accomplished by the combined effects of floating the burning oil on water and the directional force of hose streams.

Another way in which water can be used mechanically to control a fire occurs in the case of a bottom leak from a container where the escaping oil is burning on the outside and is being fed by the oil as it leaks from the tank. By adding water to the container, the fuel level may be raised above the leak to stop fuel from feeding the flames. Water for this purpose may be added to the top of the container by hose streams or pumped into a line which communicates with the tank. In either case, the rate of water addition must slightly exceed the rate of leakage, but a large excess must be avoided to guard against overflowing the tank.

Under some conditions, a hose stream can be used to stop the escape of fuel from an open end pipe or valve. If the oil is issuing at a pressure lower than the nozzle pressure, the escape of fuel can be stopped by playing a hose stream into the opening. This can often successfully be done even though the leak has already ignited. In those situations where the leak is occurring in such a way that a hose stream cannot be played directly against it, it is sometimes possible to make an emergency connection in the leaking line so that water can be pumped into the line in such a way that water, instead of fuel, leaks out of the opening.

Summary

Water is a valuable agent for extinguishing or controlling fires in petroleum products in three principal ways:

1. *As a cooling agent*, water may be used to:

a. Cut off the release of vapor from the surface of a high flash point oil, thus extinguishing the fire.

b. Protect fire fighters from flame and radiant heat when closing a valve or doing other work requiring close approach to the fire.

c. Protect flame-exposed surfaces — most effectively when the surface is above 212°F.

2. *As a mechanical tool*, a water stream can do work at a distance to:

a. Control leaks.

b. Direct the flow of petroleum product to prevent its ignition, or to move the fire to an area where it will do less damage.

3. *As a displacing medium*, water may be used to:

a. Float oil above a leak in a tank either before or during a fire.

b. Cut off fuel escape by being pumped into a leaking pipe ahead of a leak.

Fire Protection at General Motors

By Clyde W. Truxell, Jr., General Manager

Detroit Diesel Engine Division, General Motors Corporation

EDITOR'S NOTE: At the 65th NFPA Annual Meeting held at Detroit, Michigan, May 15–19, 1961, Mr. Truxell, speaking on behalf of the General Motors Corporation, extended to all members and guests of the NFPA a most cordial welcome to the City of Detroit. In his introductory remarks Mr. Truxell also spoke very highly of the work of the NFPA. Believing that our members should share our pleasure at his complimentary comments, we quote the following:

"I know of no other group that performs a more vital service, or that is composed of more dedicated people than the NFPA.

"Your minimum standards and code development work, your success in educating and promoting the use of these standards, and your functioning as a clearing house of information are undertakings which have saved untold billions of dollars and hundreds of human lives.

"We all owe the NFPA an immense debt of gratitude, and I speak not only for the General Motors Corporation, but as a parent and fellow human being."

As with any business, industry, or home, the true cost of a fire can only be determined when all of the ramifications and effects are measured.

If you mar a coffee table with a cigarette burn, the true cost is not only the refinishing of the table, but such other things as the inconvenience caused by its absence while being repaired, the strain on your emotions when your wife discovers the burn, and maybe even the look on your insurance man's face when you present your claim.

So the cost of fire is considerably more than face value. And in a large industrial organization, the cost of even a relatively small fire can be multiplied by the ramifications of dependent operations, to the point where the welfare of thousands of people and millions of dollars are at stake.

The Effects of the Livonia Fire

This was never more dramatically illustrated than by the tragic Livonia

In-plant fire equipment used at Detroit Diesel. The three-wheel industrial fire truck on the right carries 150 pounds of dry chemical and 150 gallons of water. The power-take-off pump provides 250 psi discharge pressure. The tractor-trailer unit at left was built up by Detroit Diesel. The trailer carries 300 pounds of dry chemical, ladders, hand extinguishers, and other necessary equipment.

transmission plant fire in August of 1953.* The effect of this fire was devastating. Its roar reverberated throughout the corporation — and beyond.

Here was a modern, practically new, noncombustible industrial building which met accepted standards and codes for safety. And yet, it became a completely gutted and twisted pile of rubble.

The immediate loss was huge, but the total loss was fantastic and very nearly inestimable.

There was the immediate loss of a huge investment in plant and equipment.

There was the immediate loss of employment for hundreds of people.

There was the subsequent stoppage of assembly operations at Cadillac, Oldsmobile, and Pontiac, with the attendant loss both to the divisions and their employees.

There were the cutbacks in other GM divisions which supply other components for these makes, with further loss to company and employees.

There were shutdowns in the plants of outside suppliers.

There were thousands of GM dealers without adequate inventory to meet the public demand, causing loss of sales in many cases to competitive makes, and affecting the income of the owners and employees of the dealerships.

There was the excessively high cost of crash programs to fill the void — the acquisition of new buildings, the overtime required to retool and re-equip.

And so the terrible pyramid unfolds. The flame from a welder's torch created a holocaust whose losses reached into cities and towns across the nation and even across the seas.

*For detailed report see the October 1953 NFPA QUARTERLY.

An Important Lesson from Livonia

The Livonia fire was a turning point not only for the General Motors Corporation, but for industry in general.

The lessons were painfully obvious. Industrial architecture had undergone a trend to large, single-story buildings. This type of structure was required due to industry's increasing need for fast, economical, horizontal flow of production materials.

As this type of industrial building became larger and larger, many areas of these buildings simply became inaccessible to a stream of water from an outside fire hose.

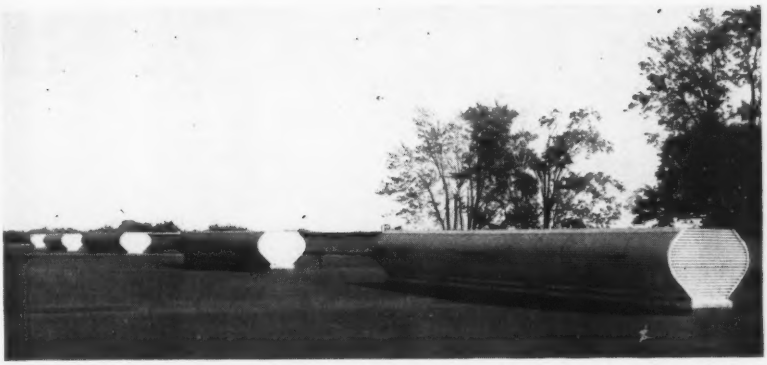
In addition, heat generated from a sizable fire deep within the structure had no immediate escape route. This built up critical temperatures within, causing failure of supporting members, even though the building materials themselves were largely noncombustible.

General Motors Postfire Program

Following the Livonia fire, General Motors instituted a sweeping program encompassing two phases: first, a thorough analysis of factors responsible for such catastrophic fires, and, second, an immediate re-evaluation of the in-plant fire brigade system and other internal controls.

As a part of the over-all program, the corporation utilized the services of a fire protection consultant and sponsored a research project on emergency ventilation at Armour Research Foundation.

Some practical answers have come out of the studies conducted in the first phase of the program.



These automatic heat ventilators are typical of many installed on the Detroit Diesel plant roof. A fusible link opens gravity-operated vents if heat builds up beneath. Vents may also be controlled electrically for added plant ventilation.

The Fire Control Plan

From the research and test work conducted, a basic plan of fire control was prepared.

This plan contains three basic parts, each of equal importance and each interdependent. They are as follows:

1. COMPLETE SPRINKLER PROTECTION IN ALL MANUFACTURING AREAS. This was deemed fundamental since it serves to keep all fires small by arresting them in the incipient stage. The outstanding performance of automatic sprinklers, that of 96.2 per cent effectiveness, has been consistent for many years and is a tribute to the sprinkler industry. The deadly fallacy of relying upon spot sprinkler protection has been illustrated in numerous catastrophes throughout the country.

2. SEPARATION OF AREAS. Although this has been a controversial subject among many authorities, the concept gradually has changed from a complete reliance upon fire walls, which do not fit too well into modern industrial design, to a consideration of draft curtains correlated with complete sprinkler protection, and with emergency roof ventilation.

3. EMERGENCY ROOF VENTILATION. Tests and experience in actual fires have shown that when emergency roof ventilation is coupled with well-designed draft curtains and 100 per cent sprinkler protection, basic fire control can be maintained and brigades can operate effectively.

The foregoing combination has been particularly effective in controlling slowly developing fires, which constitute the majority of our industrial fires. It has also been successful in controlling so-called flash fires, provided that extinguishment is completed before a large number of sprinklers open beyond the actual fire area and deplete the water supply. Operation of too many sprinklers may also cause excessive water damage.

With these three basic standards established, General Motors management immediately set to the task of putting them into effect. This was, as you can imagine, a tremendously large, expensive, and time-consuming undertaking. The program now is very nearly complete with only a few plants

remaining which still contain minor unprotected areas.

The Fire Brigade Program

The second phase of the basic program was a re-evaluation and sharpening of internal controls in each plant. To explain how this was effected, here is a description of our own operation at the Detroit Diesel engine division, which is typical of the systems now used in General Motors plants.

Our in-plant fire protection — other than the sprinkler system, draft curtains, and automatic heat vents — is based on a fire-brigade setup. Production and maintenance employees in all sections of the plant are selected from those who volunteer for duty. They are thoroughly trained on company time by our permanent fire chief in all phases of fire fighting and fire prevention.

They are equipped with two self-propelled in-plant fire trucks containing gas masks, protective clothing, fire-fighting implements, and other necessary tools of the trade.

Each shift has its own brigade, and all are under the direction of the plant fire chief. In his absence, the ranking plant protection officer assumes responsibility.

The men on the fire brigade move immediately to the scene of the fire whenever an alarm is sounded.

In the past three years, Detroit Diesel brigades have responded to twenty-two alarms and successfully contained them.

It is standard procedure to call either the Redford Township Fire Department in event of an alarm in the plant, or the Detroit Fire Department for any administration building fire.

Fire Prevention at General Motors

With our fire brigades and our built-in protective devices as our first line of defense, the area of prevention is our second prime responsibility. I put it in second place only for purposes of organization for it most certainly demands first consideration.

Our fire prevention activities fall into three general areas:

1. The reduction of the number and types of combustible materials in the plant,

2. The control of necessary hazardous substances,

3. The fire-prevention education of employees.

The first area, the reduction of the number and types of combustible material in the plant, drew special attention at the Detroit Diesel division. A survey of the plant disclosed hundreds of tanks of flammable liquids used for cleaning, leak testing, and rust-proofing. Many of these tanks were found to be no longer necessary due to changes in processes, or the movement of operations to other plant locations. The unnecessary tanks were immediately disposed of.

We found, after study, that the mineral spirits used for flushing and leak-testing castings could be replaced with a water solution containing rust-inhibiting agents. This is now standard procedure. In this case, the removal of a fire hazard also had the decidedly pleasant side effect of lowering the cost of the operation.

In operations where it was impossible to do away with a flammable material, we found that in many cases we could use solvents with safer, higher, flash points.

Our current use of mineral spirits is restricted to those operations which require quick drying, such as parts moving to the paint booths.

We also examined our hydraulic oils and specified a fire-resistant type for use in all areas where heat or ignition sources were present. In the course of this investigation, a flammable hydraulic fluid was found being used on a door-actuating and furnace-loading operation. The possibility of that line rupturing and igniting under pressure was a constant worry, until the fluid was replaced by a fire-resistant type.

These activities at Detroit Diesel were typical of the quest for greater safety in all GM plants during this period.

Hazardous Material Control Committee

Another General Motors safeguard, which you will find in any plant requiring it, is a Hazardous Material Control Committee. The function of this committee is to establish safe methods for the storage, handling, and disposal of materials defined as having a potential for causing fire, explosion, toxicity or corrosion, either by themselves, or in combination with other materials.

One of the most important functions of the committee is to approve the purchase of all hazardous material. No materials, not even samples, can be procured without committee approval.

In addition, the committee is responsible for issuing to all plant supervisors a "Hazardous Materials Manual" which describes the properties, physical characteristics, and safe requirements for the procurement, use, and disposal of all hazardous materials used at Detroit Diesel.

Employee Safety Education

The third area, which occupies our attention, is the constant safety education of employees. "Seven Basic Principles of Safety," written by Mr. John Gordon, the president of the General Motors Corporation, is the foundation for all General Motors plant safety programs. It is no coincidence that five of these principles deal with the safety education of the employee.

At Detroit Diesel, we are especially proud of a system which we devised as a part of our over-all plant safety program, but which encompasses fire safety as well.

The Detroit Diesel fire brigade is shown using a fog applicator on an oil fire in the training tank during a regular training session.

We call this program UPO — Unsafe Practice Observation. This is a supervisory participation program designed to instill in our supervision a sense of "hazard awareness." The basis for the program is an intensive training program designed to teach our supervisors the many types of industrial hazards and how and where to spot them, but more than anything else, to create an awareness of the unseen, unsuspected, or undeveloped hazard. A series of incentive awards was established to stimulate prompt action by a supervisor, once a hazard or potential hazard was spotted.

The results have been more than gratifying. In 1960, Detroit Diesel supervisors found and corrected 2,037 hazardous conditions or practices. Of this number, 119 were directly or indirectly conducive to fire.

To some of you, 2,037 hazardous conditions in one year may sound as if we are running a veritable snake-pit. Actually, due to the "hazard awareness" of our supervisors, the majority of these were minor hazards. Our safety record is one of the best, and we feel our UPO operation is one of the reasons for it.

Another pleasant by-product of our eight years of "Unsafe Practice Observations" is the increasing frequency with which our nonsupervisory employees bring our attention to fire or accident hazards. This, of course, is a tribute to the truism that the attitude of management will be found reflected in the attitudes of employees.

This is evident not only in our own plant, but holds true for the total corporate structure. The enlightened approach found in General Motors divisions and plants is merely a reflection of the enlightenment of General Motors top management, which has had the courage to move forward and make the decisions and expenditures necessary to implement these protective measures.

As a result, GM employees today are safer at work than at home. And we have tremendously reduced the risk of jeopardizing the operational continuity of corporate activities.

Constant Vigilance Required

I do not wish to convey the thought that since these safeguards have been put in effect, we have promptly disposed of our attitude of caution. As you well know, the price of safety is vigilance. Our role is now one of constant vigilance to assure that our automatic systems are functioning properly and that our people remain alert to meet existing or new hazards.

Even with the fine protection which we believe we have, there is always the possibility of a sudden explosion which could render the automatic elements useless. It is such an unpredictable catastrophe as this that makes us such ardent advocates of the NFPA.

GM and the NFPA

At the present time we are proud that a number of our people are taking active parts in the NFPA. John Ahern is serving as chairman of the Committee on Electronic Computer Systems. Mr. John R. Marshall of Fisher Body division serves on the Finishing Processes Committee; Mr. Claude H. Leland of the manufacturing staff is on the Committee on Ovens and Furnaces; and Mr. Harry F. Blankenship of Chevrolet Motor division is a member of the Truck Transportation Committee.

Through the services available from this organization and the information exchanged, we hope both to contribute to, and avail ourselves of, the increasing store of knowledge to be gained in the years ahead.

Interstate Forest Fire Protection Compacts

By W. J. Stahl and J. N. Diehl

Division of Cooperative Forest Fire Control
Forest Service, U. S. Department of Agriculture

It is considered economically unsound to provide a full measure of manpower and equipment on a permanent basis to meet unusual forest fire conditions which occur only infrequently.

Adequate forest fire protection can be provided at a minimum cost by maintaining a basic organization manned and equipped for the usual fire situation, but capable of rapid expansion and with flexibility to meet emergency situations successfully. Such organization must be supplemented by planned use of all available cooperative forces. Interstate forest fire protection compacts provide a means of getting a fully trained cooperative force on the ground at a minimum cost to meet emergency situations.

History of the Interstate Compacts

Interstate compacts are authorized by specific Acts of Congress as called for by the Constitution (Article 1, Section 10), "No state shall, without the consent of Congress . . . enter into any Agreement or Compact with another state. . . ." From time to time, since 1917, the National Conference of Commissioners on Uniform State Laws has reported favorably on the need for greater use of the compact device to overcome obstacles to commercial or social welfare.

The compact, a mutually binding agreement, was originally used by states sparingly and chiefly in connection with settlement of boundary disputes and cession of territory or jurisdiction. More recently compacts have been used to promote cooperation between states in such activities as construction and use of bridges and tunnels, the apportionment of water, labor development, improvement of navigation, flood control, sanitation and abatement of pollution, conservation of fisheries, recreation, crime prevention, and regulation of oil production. During the past ten years, compacts have been used in increasing numbers and variety to solve interstate problems, encouraged by the general or blanket authorization by Congress for making compacts between two or more states. The first such authorization, national in scope, was that of March 1911, "for the purpose of conserving the forests and the water supply" (Weeks Law, 36 Stat. 961).

It was only natural that serious and disastrous forest fires would result in fire fighting agencies seeking the benefits of mutual aid provided by compacts. The purpose of interstate forest fire protection compacts is to obtain cooperation among member states in preventing and suppressing forest fires. Compacts clarify numerous legal questions involving liability, damage, salaries, and expenses when outside aid is requested by a state.

Northeastern States Compact

Since the Northeastern Interstate Forest Fire Protection Compact was the first of the forest fire protection compacts, a detailed review of its development will be enlightening. In January 1948, a

meeting was held under the auspices of the Massachusetts Commission on Interstate Cooperation, with the assistance of the Eastern Representative of the Council of State Governments. The meeting was called chiefly at the instance of volunteer fire company organizations and insurance companies. The heavy forest fire losses in New England in 1947* were cited as one reason for the need for closer cooperative relationships among states and the need of fire companies to have a better understanding of their responsibilities outside of their own jurisdictions. The meeting was attended by representatives of the New England States and New York, including the state foresters of these states.

Subsequent to this meeting and a meeting of the state foresters in August 1948, a proposed draft of a compact dealing with forest fire control was prepared by the Council of State Governments and sent to the state foresters and other state representatives involved.

At a meeting in December 1948, the proposed compact draft was reviewed by a committee of state officials, including foresters, fire marshals, commissioners on interstate cooperation, and others. The comments and suggestions developed at the meeting were incorporated in a revised draft which was subsequently approved by an Executive Committee designated at the meeting.

The next step was to request the attorney general of each state involved to review the proposed compact, and to draft enabling state legislation which would implement the compact in his own state. The compact must be uniform in all member states.

Congressional Consent Obtained

The interest in forest fire compact development in New England and New York was made known to the Congress

*See Maine Forest Fires, January 1948 QUARTERLY.

Maine, October, 1947. Nine major fires burned 250,000 acres during the month. Between 100,000,000 and 150,000,000 board feet of "saw timber" were destroyed, more than 1,200 homes leveled and some 6,000 persons were made homeless.

Among the lessons of these fires was the need for greater over-all coordination for large scale fire control operations.

of the United States. This resulted in PL 129 81st Congress, approved in June 1949, in which consent and approval was given to an interstate forest fire protection compact to promote effective prevention and control of fires in the northeastern region of the United States and adjacent areas in Canada. The law calls for development of integrated forest fire plans, maintenance of adequate forest fire fighting services by the member states, mutual aid in fighting forest fires among the states of the region, and procedures that will facilitate such aid. The law also authorizes the establishment of a central agency to coordinate the services of member states and to perform such common services as member states may deem desirable. Congress, by the same law, in giving its consent to the inclusion of adjacent areas in Canada, required that before any province of Canada shall be made a party to the compact, the further consent of the Congress shall first be obtained.

In May 1952, PL 340 82nd Congress was enacted granting the consent and approval of Congress to the participation of certain provinces of Canada in the Northeastern Interstate Forest Fire Protection Compact. The act clears the way for the northeastern states and contiguous Canadian provinces to join hands in an international organization to fight fires on either side of the border. Informally the fire fighting crews from Maine have worked with those in Canada in the development of integrated fire protection programs.

The Northeastern Interstate Forest Fire Protection Compact is especially significant because of its international aspect, laying the basis for agreement between several states of the United States and the provinces of Canada through the compact process rather than through the process of treaty-making by negotiation between the United States and Canadian Governments.

Expansion Permitted

By its terms, the compact is operative as to the ratifying states when any two have ratified it. It also provides that any state not named in the compact which is contiguous with any member state may become a party to the compact. Subject to the consent of the Congress, any province in Canada which is contiguous with any member state may become a party by taking such action as its laws and the laws of Canada may prescribe for ratification.

Advisory Nature of Compact Commission

Other terms of the compact of general interest provide, in Article III, for a commission consisting of three representatives of each member state. One of these representatives shall be the state forester or other state official responsible for forest fire control; the second a member of the legislature; the third a representative of the governor.

Article IV authorizes the commission to study methods of preventing and controlling forest fires in the member states, to coordinate protection plans of member states, and to facilitate interstate aid in forest fire control especially during emergencies. The duties of the commission are advisory rather than administrative, although Article V provides that two or more member states may designate the commission to perform for them specified administrative functions. Presumably these might include such services as sponsoring a program for better forest fire prevention, testing and making specialized fire control equipment, or any of the numerous fire control measures for which the states have a common need.

Article VI states that the commission may ask the U. S. Forest Service to act as its research and coordinating agency.

Regional Forest Fire Plan

Article VIII requires each member state to integrate its forest fire plan with the regional forest fire plan which the commission will formulate. Each state forest fire control agency will aid other member states and Federal agencies in preventing and controlling forest fires.

Liability Is Requesting State's

Article IX places all liability upon the requesting state where fire control forces of a member state go to the aid of another member state.

The Budget

Article X states that the commission will submit to the governor of each member state a budget of its estimated expenditures. It specifies how the costs of supporting the commission and its services will be allocated among the member states.

Responsibility of Individual States

Article XIII of the compact makes it clear that in large measure each state must continue to rely upon its own efforts to achieve adequate forest fire control. The commission, however, will be in a position to analyze the strength and weakness of the measures taken in each state and to recommend to the respective governors and legislators such improvements as it judges necessary.

There is no authority for the commission to compel, by force or penalty, the carrying out of any of its projects by any member or state. Membership in the commission is voluntary and may be terminated at any time upon due notice. No state is under obligation to give aid to a sister state unless it can do so without unduly weakening itself at home. Although the compact provides that each state shall render aid to the U. S. Forest Service, or to other agencies of the Federal Government, in combating, controlling, or preventing forest fires in areas under their jurisdiction located within the boundaries of that state, these Federal agencies do not become members of the commission.

Organizational Meetings

Following the passage of the act and the ratification by all states named in the compact, except Rhode Island, and the appointment of commissioners from each state, an organizational meeting was held in January 1950 to discuss preparation of rules and regulations for the operation of the compact commission, financing, and the appointment of a staff director. The Council of State Governments assisted in drafting the rules and regulations to be presented at the next meeting. An executive secretary was employed and a budget approved. The necessary funds were obtained by assessing each state in proportion to its forest area.

At subsequent early meetings, consideration was given to the preparation of state and regional fire plans, variations in forest closure procedure, need for training key personnel, civil defense plans, and the entrance into the compact of the Canadian Provinces of New Brunswick and Quebec. A Technical Committee was formally approved, this to be a "steering" committee on all technical matters confronting the commission. Proposed training programs were reviewed in detail; standardization of equipment was discussed, as was pooling of purchases of equipment. In addition to the Executive Committee (a group within the Compact Commission) and the Technical Committee, subcommittees of the Technical Committee were established — communications, equipment standardization, and a training team. Study committees are also established for such phases as fire protection, legislation, equipment, training and policy. The training program,

as developed, made it possible for the commission, on short notice, to assemble from the several states uniformly trained supervisory personnel capable of functioning as well coordinated, smoothly operating teams to handle large fires anywhere in the region.

Executive Secretary's Duties

The executive secretary of the commission acts as compact dispatcher in times of emergency. In order to be effective, he collects from each state lists of fire suppression facilities and equipment, organization maps, lists of permanent state fire fighting personnel, knowledge of the fire situation, etc. The critical droughts of recent years have resulted in compact action, such as the request from New Hampshire in August 1952 for pump operators. This request was referred to Vermont by the dispatcher. Vermont then contacted New Hampshire and made arrangements to furnish the needed manpower. When Maine requested aid in August 1952, a New York plane delivered a load of pumps and hose to Maine. There are more examples of compact action.

Permission to Cross State Lines

In order that the fire fighting forces of any state might legally cross into another state for fighting fires which threaten to cross state boundaries, a Request for Continuous Mutual Aid in the suppression of such fires has been prepared and sent to the various states for execution. When signed by the states involved and filed with the Northeastern Interstate Forest Fire Protection Commission, these instruments operate to bring such suppression activities across common state boundaries fully under the terms of the compact without the delay or necessity of a formal request to the compact dispatcher for aid at the time of an emergency.

Interstate Training Program

Interstate training sessions last about three days and are held annually. Subject matter is prepared in lesson plan and narrative form and presented by the compact training team to about forty trainees. The trainees then become training officers in their own states. In order to make lesson material more available, the commission published, in 1954, a "Manual for Fire Control Organization"* for reference use.

This manual has had wide use in the United States, Canada, and overseas. In 1958, a second manual "Forest Fire Fighting Methods and Techniques"* was published. The training team plans full dress field exercises which will simulate actual field conditions on a mutual aid operation, and which will emphasize the points brought out by the critiques of other exercises on organization.

Southeastern States Compact

Other forest fire protection compacts followed the lead of the Northeastern States Compact. In May 1953, during the Southern Regional Conference of the Council of State Governments, representatives of eight southeastern states (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee) discussed forest fire protection problems and the advantages of an interstate forest fire protection compact. The severe droughts of 1952 and 1953 in the southeastern states indicated a need beyond the capacity of a single state when a forest fire disaster strikes. The interest engendered at the May meeting culminated in the enactment of PL 536 83rd Congress, Chapter 581, 2nd Session, July 27, 1954, which permitted the formation of the Southeastern Interstate Forest Fire Pro-

*This publication may be obtained from the Northeastern Forest Fire Protection Commission, Chatham, N. Y., for $1.50.

tection Compact. This compact included the states of Virginia and West Virginia in addition to those mentioned above.

Southeastern and Northeastern Compact Differences

This act follows the general pattern of the Northeastern Compact. Major differences are:

1. It provides for mutual aid among the states in the Southeastern Compact with states which are party to other interstate forest fire protection compacts. This provides "swing" states which may be a party state in two or more compacts.

2. There is no commission such as in the Northeastern Compact. In its place, the state forester in each party state is a compact administrator. The compact administrators, along with the Advisory Committee, do work such as is assigned to the commission in the Northeastern Compact, described previously in this article. The Advisory Committee from each state is comprised of one senator and one member of the House of Representatives (who are designated by the State Commission on Interstate Cooperation) and two members appointed by the governor of the state, one associated with forest or forest products industry.

3. There is no provision for assisting the U. S. Forest Service and other Federal fire fighting agencies.

4. There is a proviso that nothing in the act shall be construed as relieving any person from liability for his own negligent act or omission, or as imposing liability for such negligent act or omission upon any state.

5. The Southeastern Compact does not provide for allocation of costs among member states or the acceptance of donations, gifts, and grants.

6. It does not provide for a paid executive secretary.

The Compact Commission

The organizational meeting of the Southeastern Compact was held in October 1954 with a representative of the Council of State Governments present. After discussion of the type of organization, it was agreed that the compact administrators and the Advisory Committee would comprise the commission. It was agreed that the commission would have an executive committee of five members which consist of a chairman, vice chairman, secretary, and two other members. At any time, the members of the Executive Committee shall include three state foresters and two persons who are not state foresters. It also agreed that the chairman of the commission shall serve as coordinator (dispatcher) in situations in which adjoining states cannot effectively solve their emergency fire problems.

Subsequent annual meetings led to the appointment of committees to effectuate the further development of the commission: committees such as Rules and Bylaws, Reimbursement and Standard Charges, Blanket Insurance Policy, Communications, Regional Fire Plan, Manual, Personnel Training, and Safety. Provision was made for State Interim Continuing Committees to function until state ratification was obtained. The training team functions much as that of the Northeastern Compact. There have been annual compact-wide field fire exercises. An organizational manual was prepared and published in 1957. It covers organization build-up from a small crew fire to a large campaign fire.

In accordance with the desires of the compact commission and the action of the Executive Committee in January

1957, the Regional Forester of the U. S. Forest Service, Region 8 in Atlanta, Georgia, agreed to appoint from the forest service a compact coordinator and a deputy coordinator. The duties of the coordinator are to maintain current lists of manpower and equipment, to maintain records of fire situations and the weather, to handle procurement of assistance for requesting states, and, with the approval of the Executive Committee, to initiate and plan training programs and to execute plans and prepare annual reports.

Compact action has been taken a number of times. Georgia, for example, has frequently sent water-bombing planes to other states.

South Central States Compact

The 1952–53 drought that was prevalent in the states of the Southeastern Compact also was felt in the states which are members of the South Central Interstate Forest Fire Protection Compact — Arkansas, Louisiana, Mississippi, Oklahoma, and Texas. There was need for mutual assistance during critical fire periods. This need was reflected in the enactment of PL 642 83rd Congress, Chapter 891, 2nd Session, approved August 1954. This act is almost identical with that authorizing the Southeastern Compact.

The organizational meeting for the South Central Compact was held in November 1954. A representative of the Council of State Governments was present. A decision was made as to the official name of the administrative body: South Central States Forest Protection Compact Commission. The commission will be composed of the compact administrators and the Advisory Committee. The compact administrators will be the state forester or officer holding the equivalent position in each state. The Advisory Committee is composed of four persons from each state. The Executive Committee will be two members from each state selected by the five representatives from that state, one to be the state forester. The commission officers are a chairman, vice chairman, and secretary, selected from the membership of the Executive Committee, the chairman to be a compact administrator. The vice chairman and secretary may be chosen from the total membership of the commission.

In this compact, the chairman of the commission is the compact dispatcher and is responsible for the functions assigned to the executive secretary in the Northeastern Compact and the compact coordinator of the Southeastern Compact. In other respects, the over-all action, policies, and procedures are like that described for the Southeastern Compact.

There have been no compact-wide project field fire exercises, but two or more states in the compact have had such exercises. A fire manual has been prepared and distributed.

The compact has been used in several instances to provide assistance to member states.

Middle Atlantic States Compact

Early in 1956 some Mid-Atlantic states became interested in interstate forest fire protection compacts. This resulted in the enactment of PL 790 84th Congress, Chapter 719, 2nd Session, approved July, 1956. The resultant Middle Atlantic Interstate Forest Fire Protection Compact includes the states of Delaware, Maryland, New Jersey, Pennsylvania, Virginia, and West Virginia.

The authorizations under this act are very similar to the Southeastern Compact in that the purpose is to obtain cooperation in preventing and sup-

pressing forest fires and to provide for individual state fire plans and an integrated regional fire plan. Compact administrators, or the state forester or comparable official from each state, would coordinate the services of member states and provide administrative integration in carrying out the purposes of this compact. The state requesting aid would be required to assume costs of states rendering aid. Each state would have to assume its own liability for injury and death benefits. It would authorize the compact administrators to request the Forest Service to act as the research and coordinating agency of the compact. The bill would not affect existing or future cooperative relationship or agreement between any Federal agency and member state or states.

There has been no organizational meeting, so this compact remains inactive.

Other Possible Compacts

The four compacts described above constitute the present formal mutual aid efforts among states in forest fire control. There has been much discussion of the need of such compacts elsewhere among states, but no action has been taken toward initiation. There is the possibility that an arrangement might be worked out for the lake states: Michigan, Wisconsin, and Minnesota, which would be of material assistance in meeting the extraordinary needs of severe emergency periods. The Canadian Provinces of Ontario and Manitoba might very properly be interested in such an organization.

A compact may be the solution to effective action during periods of extreme fire danger in Missouri, Iowa, Illinois, Indiana, and Ohio. At the time the South Central Organization was initiated, Missouri indicated that she could not join a compact.

The Northwest, with the large forest areas of Washington, Oregon, Idaho, and Montana, might prove to be the next area with more than a casual interest in a compact. This is an area of extremes in fuel hazard and weather. An over-all supporting organization which would provide the mechanics of securing outside aid in emergency may prove of great assistance to any one state. At the present time, the large Federal fire fighting organizations of the Forest Service and the Bureau of Land Management seem to provide the cooperation needed by the state and association organizations. Several Canadian provinces might also be interested in such a compact.

There is also the possibility that a Pacific Coast Compact including Washington, Oregon, and California may be the organization which would best meet the need for mutual assistance.

Forest fire compacts are working. They fill a very important need. The type of organization of a particular compact group must follow the recognition of specific needs.

Protecting the Buyer of Record Protection

By R. B. Strawn, San Francisco Branch Manager

Diebold, Inc.

Ashes will not support accounts receivable claims. Cremated cards are of no interest to an insurance company asking for proof of inventory losses.

The Early Days of Record Protection

For many years there was no yardstick available by which the purchaser could be assured that a device he had bought would protect his records against fire damage. Many claims were made by manufacturers for the fire resistance of equipment they produced, based on various tests of their own creation. Each manufacturer had his own insulation mixture — a jealously guarded secret — on which the fire resistance qualities of the device depended. The buyer had the impossible task of evaluating claims and counterclaims which had no common denominator. The tests were crude compared with modern-day procedures and, in fact, often did not include reliable means of evaluating the actual protection afforded to the contents.

A so-called "lamp chimney test" was used to evaluate the suitability of the insulating mixture. In this test a glass lamp chimney was filled with wet insulation and allowed to dry to hardness. If the chimney cracked, the insulation was not suitable because it would swell and prevent doors from closing. If the mix shrank and rattled in the chimney, it was not acceptable because it would not stay put in vital corners and jamb contours.

Present-Day Safeguards

It is still true that each manufacturer has his own insulation formula, but today, testing by an impartial, nationally recognized fire testing laboratory gives purchasers a fire resistance rating for each device tested. This has come about through the establishment of test procedures by Underwriters' Laboratories, Inc. Safes and other record containers, to be eligible for the "UL" label, must be so constructed that paper records will be "handleable and decipherable by ordinary means" following exposure of the equipment to standardized test fires. By purchasing record protection equipment bearing the UL label, the buyer can now select a unit with a fire protection rating commensurate with his fire hazard (up to four hours for safes or six hours for vault doors).

The Underwriters' Laboratories, Inc., first published their Standard for Fire Resistance Classification of Record Protection Equipment* in 1917. Any safe or other record protection device made prior to that date is of unknown quality. Any unlabeled unit made since that time must necessarily also be considered to be of unknown quality. The only way to determine the value of an unlabeled

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Presented by Mr. Strawn at the 65th NFPA Annual Meeting, Detroit, Michigan, May 15–19, 1961.

*Now published in pamphlet form, Subject 72, Seventh Edition, July 1952.

This insulated cycle billing desk carries the UL Class C, 1-hour label and the SMNA label.

The UL label signifies that the unit has been subjected to a standardized fire of controlled extent and severity for 1 hour, reaching 1,700°F, before an interior temperature of 350°F was reached. Interior temperatures were measured 2 inches from the top of each insulated compartment occupied by contents and 1 inch from the side walls, 1 inch from the back, and 1 inch from the inner face of each drawer head and other closure.

The UL Class C label also indicates that the container underwent a sudden heating (2,000°F for 30 minutes) without producing an explosion sufficient to cause an opening into the interior, and that the container underwent the following impact test without destroying the usability of papers stored inside: it fell 30 feet in the clear after being heated for 30 minutes and, after impact, was reheated in the inverted position for 30 minutes.

The SMNA label means that this billing desk conforms to the exacting specifications of the Safe Manufacturers National Association.

unit is to subject it to fire. The knowledge thus gained, however, is useless, since safes, like matches, can only be burned once. This limitation also establishes that a "used" safe is a highly questionable item. If a penny-conscious purchaser buys a "used" safe that has been repainted after coming through a fire, he has obtained a good incinerator, but a worthless protector for his records.

Active Insulation

All safes depend upon their insulation to provide the desired degree of fire resistance. Some people have inquired why heavy or expensive components like cement, diatomaceous earth, vermiculite, and gypsum are used instead of relatively inexpensive materials such as rock wool, expanded mica pellets, and reflective aluminum. These latter items are not suitable because they are passive and inert, depending upon dead-air space or reflectivity for their effectiveness. Such insulation materials are fine for attics, but are no good for safes. Safe insulations must be active, must "work" to dissipate heat — literally use it up to prevent its penetration to the records stored inside. Paper is in trouble when exposed to temperatures above 350°F.

Safe manufacturers have found methods of making insulations that will "work." While the manufacturing methods may vary, the end results are the same. All safe insulations depend for their effectiveness on water. A block of insulation does not look as if it has much water in it, but if it is weighed, desiccated and weighed again, it will weigh up to 30 per cent less. The water is held partially in crystalline form and partially by ordinary mechanical means.

When a safe is subjected to fire and is brought up to the temperature at which water boils (about 212°F), the insulation begins to steam. As long as it can steam and give up moisture to dissipate the heat, it will protect the contents of the safe. Once this water has been driven off by heat, there is no way to restore the insulation to its original condition.

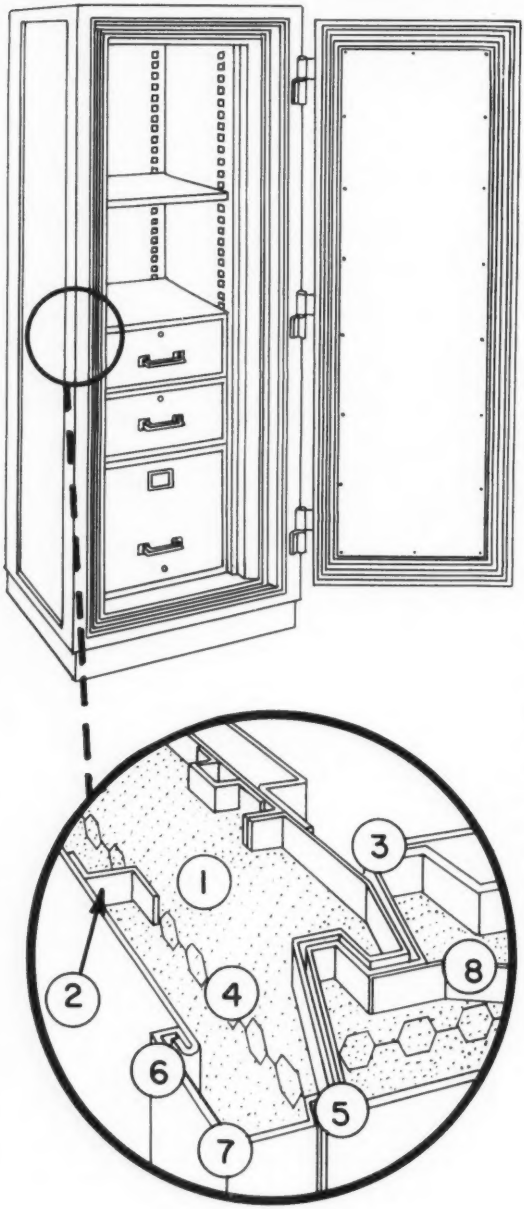
Today it is possible to obtain properly insulated safes, insulated files, ledger tray safes, fire-resistive vault doors and other special-purpose insulated containers. Fire-resistive ratings are attested to by the presence of UL and SMNA labels on these products. Depending upon the product, these labels may indicate fire-resistive qualities of ½ hour, 1 hour, 2 hours, 4 hours, or 6 hours (vault doors only).

Organizations Promoting Record Protection

The UL label on record protection equipment indicates how severe a fire the equipment can endure without damage to its contents. To assist the purchaser in selecting the proper equipment for his particular needs, the NFPA Committee on Protection of Records has prepared the publication Protection of Records (NFPA No. 232).* This guide contains information essential to purchasers on how to evaluate the fire exposure hazard, the advantages, and limitations of the various types of record containers; it suggests a program for retention, classification, and disposal of records; and it recommends methods of salvaging fire-damaged records.

The Safe Manufacturers National Association, Inc., has contributed to the quality of record protection. One of the objectives of this Association of record container manufacturers is "to establish and enforce such proper and lawful procedures as will safeguard the public against improper claims as to the fire

*Published in National Fire Codes Vol. III and in separate pamphlet form, $1.00 per copy.



Partial section through a corner of UL Class B, 2-hour Diebold, Inc., safe. Construction details shown are: (1) insulating material, (2) one of the fasteners that tie insulation and steel shells together, (3) interlocking construction principle providing a barrier against heat and flame where wall and door join, (4) wire netting to protect insulation from cracking under impact, (5) welded key contact joints, (6) special assembly of body plates and corner posts to permit expansion and contraction in severe heat, (7) overlap corner posts for additional structural strength, (8) baffle plate at door joint to retard transfer of heat to inside of safe.

and/or burglary resistance of products of the industry."

To this end the Safe Manufacturers National Association, Inc., requires compliance with UL standards by all SMNA members. An SMNA label on record protection equipment means to the purchaser that the manufacturer subscribes to the Code of Ethics of the SMNA. A UL label signifies that the equipment complies with the UL requirements applicable to the particular device.

The SMNA also continually investigates claims made for fire-resistive equipment by all manufacturers. There are many instances where the SMNA has enlisted the help of the Better Business Bureau, record container manufacturers, Underwriters' Laboratories, Inc., and others to stop false claims and misleading advertising.

The SMNA has cooperated closely with the NFPA in many ways, one of which is to furnish reports (where available) of the performance of fire-resistive equipment in actual fires. It has worked with Underwriters' Laboratories, Inc., in establishing standards for various types of new equipment and in keeping existing standards up to date. The SMNA also acts as technical and industrial advisor to the National Bureau of Casualty Underwriters.

Incinerator Design

By G. H. Willett, Jr., President

Incinerator Products Company of Detroit
Charter Member, Incinerator Institute of America

EDITOR'S NOTE: At the 1961 NFPA Annual Meeting, Mr. Willett presented a paper entitled "Engineered Destruction," in which he described present-day incinerator design. He emphasized that modern incineration equipment is engineered to destroy combustible refuse safely and quickly. Slides shown by the author to illustrate this point are reproduced in this article.

Mr. Willett gave the principal credit for the high level of efficiency in incinerator design to the standards of the Incinerator Institute of America (IIA), an association of incinerator manufacturers formed in 1950.

Direct Fed Incinerator

The direct fed incinerator (see Figures 1, 2, and 3) is designed to incinerate what is called by the Incinerator Institute of America (IIA), Type 1 waste (papers, cardboard, rags, wood scrap). It can also be used for Type 2 waste (approximately equal mixture of rubbish and garbage by weight). There can be up to 50 per cent moisture and 7 per cent noncombustible solids in Type 2 waste.

The IIA standards contain the following requirements for direct fed incinerators:

1. Both a primary and a secondary combustion chamber.

2. Interior large enough so that the total heat release (excluding heat from the ash pit) will not exceed 25,000 Btu per cubic foot per hour.

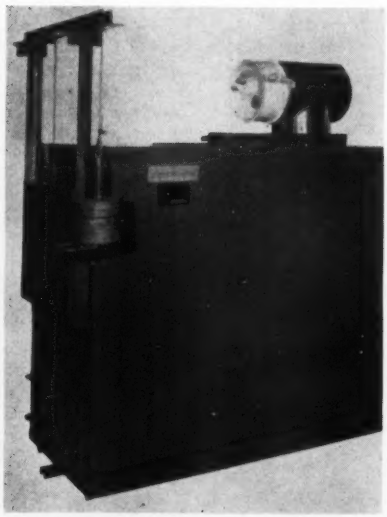


Figure 1. Exterior view of typical direct fed incinerator. Exterior walls are steel with refractory lining. This class of incinerator can be used in schools, stores, factories, and offices.

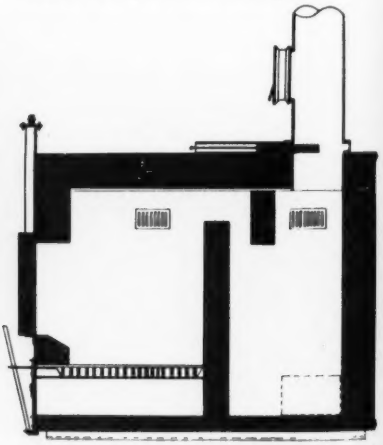


Figure 2. Sectional view of the direct fed incinerator shown in Figure 1.

3. Adjustable opening for secondary combustion air (overfire air) in both the primary and secondary combustion chambers to be not less than 2 square inches per square foot of grate area.

4. Refractory damper.

5. Barometric damper in a size not less than three-fourths the area of the breeching or stack in which it is located.

6. Cast-iron grates.

7. Refractory lining not less than 4½ inches thick in incinerators with capacities up to 500 pounds per hour, and 9 inches thick in units of over 500 pounds per hour capacity.

8. Exterior walls 8-inch-thick common masonry, or steel of not less than 12-gage thickness. If masonry, a minimum air space of 1 inch between the lining and exterior wall.

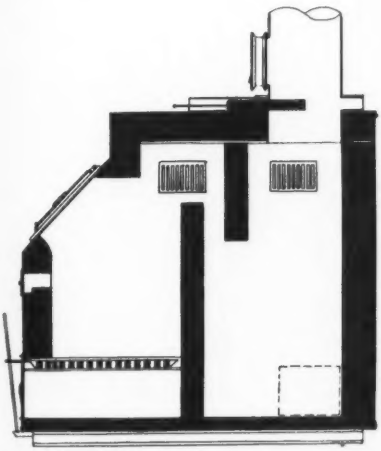


Figure 3. In some parts of the country an inclined charging door on direct fed incinerators is preferred.

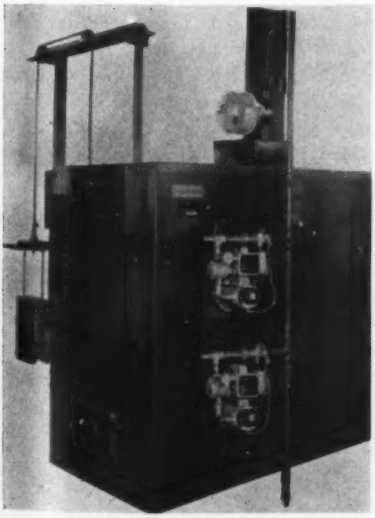


Figure 4. Typical pathological incinerator. It is available with the straight front as shown or with an inclined loading door.

Pathological Incinerator

Pathological incinerators (see Figures 4 and 5) are designed to consume animal remains from hospitals, laboratories, abattoirs, and other occupancies having organic wastes. Because the moisture content of such wastes averages 75 per cent, a gas or oil burner is required in the primary chamber to assure complete combustion. To pre-

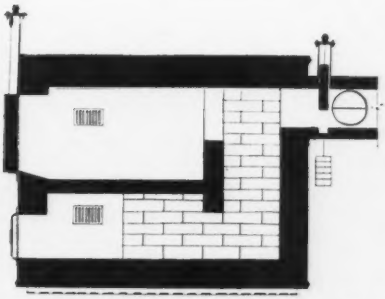


Figure 5. Sectional view of pathological incinerator. The waste is placed on the refractory hearth. Products of combustion pass over a bridge wall and down through a mixing chamber to the secondary combustion chamber.

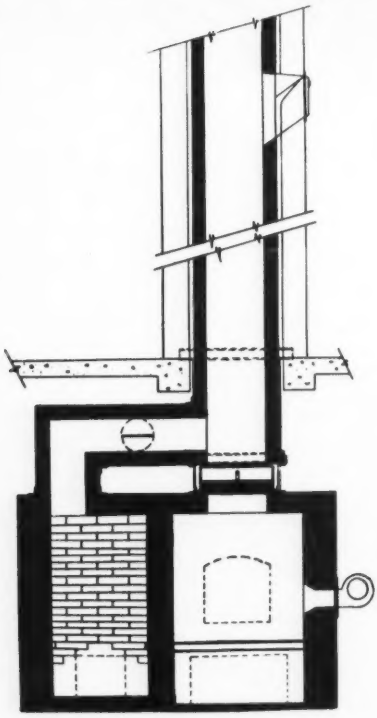


Figure 6. Sectional view of flue fed incinerator. As shown here the horizontal sliding door above the primary combustion chamber is in the closed position it would occupy during combustion.

vent the escape of odors, a burner is also provided in the secondary chamber. One square foot of hearth is required for each 10 pounds per hour of rated capacity. Other design requirements are the same as those for direct fed incinerators.

Flue Fed Incinerator

As its name infers, the flue fed incinerator (see Figure 6) is charged through openings in the flue at each story of the building. It consists of a primary combustion chamber, a mixing chamber, and a secondary combustion chamber. During the period when the incinerator may be charged, which usually coincides with the period during which the building is in use, the horizontal sliding door at the base of the flue and above the primary chamber is open. On being energized by a time clock mechanism, a magnet locks the door closed in each charging opening in the flue. The clock also actuates a water-operated cylinder that closes the horizontal sliding door above the primary chamber, and starts the gas burner. At the end of a predetermined period, which is long enough to permit complete combustion of the refuse, this procedure is automatically reversed, so that the incinerator is again ready for charging.

LP-Gas Fires and Explosions

An NFPA Staff Study

The use of liquefied petroleum gases, including propane, butane, and various mixtures, has expanded rapidly since the early 1920's until presently it is estimated that over ten billion gallons will be used in the United States in 1961.

The fire and explosion experience with liquefied petroleum gas installations has been generally favorable in relation to the large scale use of these products. Fires and explosions, however, have occurred where the safeguards outlined in NFPA standards have not been observed.

NFPA LP-Gas Standards

The NFPA Committee on Gases has kept in close touch with the problems associated with the growing use of liquefied petroleum gas and has been preparing standards for the safe handling and use of these products for thirty-seven years. The standards have been revised from time to time to keep them technically adequate, practical, and up to date. The latest revision, 1961, is entitled Standard for the Storage and Handling of Liquefied Petroleum Gases (NFPA No. 58). It covers the fundamental characteristics of these products and the proper methods used in handling them in storage and transportation.

Standard No. 58 has either been adopted in full or used as a reference in all of the 50 states as well as the provinces of Canada. It is followed by virtually the entire LP-Gas industry, which refers to it as its bible.

The installation of LP-Gas burning equipment for domestic and commercial use is covered in the Standard for the Installation of Gas Appliances and Gas Piping (NFPA No. 54). The recommendations in No. 54 apply to all installations except those in mobile homes and travel trailers. The latter installations are covered in NFPA No. 58 and in the Standard for Fire Prevention and Fire Protection in Mobile Homes and Travel Trailers (NFPA No. 501B).

News Press, Savannah

Meldrim, Ga., June 28, 1959. Derailment of 16 freight cars, including two LP-Gas tank cars, was followed by an explosion and fire that killed 23 persons in a nearby picnic area.

Studies of LP-Gas Experiences

Many reports of fires and explosions involving LP-Gas have been received by the NFPA Fire Record Department. Summaries of more serious cases and representative samples of "run-of-the-mill" incidents were first presented in the January 1942 QUARTERLY (Volume 35, No. 3); then a 20-year study was published in the July 1952 QUARTERLY (Volume 46, No. 2). Reprints of the 1952 study are available.

The present study covers the reports of fires and explosions received by the NFPA Fire Record Department during the past 8 years. Typical incidents, grouped by occupancy for convenient reference, are presented as examples of the types and severity of accidents that can occur if the properties of LP-Gases are not understood and if safe practices in their handling are not followed.

An effort has been made to present factually correct accounts, but complete verification has not been possible in all instances.

In the 156 cases reviewed herein, 128 persons were killed and 595 were injured.

LP-Gas, like oil burning equipment, electricity, and other sources of heat and power possessing inherent hazardous properties, can be used safely if recommended standards for its storage, handling, and use are followed. It is significant that in practically every one of the following reports, where sufficient data could be obtained to determine the contributing factors, evidence was clear that some deviation from the principles set forth in Standards No. 54 or No. 58 was primarily responsible for the fire or explosion and extent of damage.

It is also significant that in most cases the results would have been the same with natural gas, manufactured gas, gasoline vapor, or any other type of combustible gas. The present study covers only cases where LP-Gas was involved, including so-called bottle gas.

Analysis of 250 Fires and Explosions

The NFPA Fire Record Department analyzed significant data in reports of 250 typical recent LP-Gas fires and explosions in its files. Sources of the escaping LP-Gas involved in these cases were as follows:

Tank trucks	49
Piping	40
Heating equipment, except stoves	38
Cylinders	30
Storage tanks	28
Vehicle fuel tanks	21
Stoves, other appliances (except heating equipment)	14
Vehicle engines	10
Miscellaneous known sources	6
Unknown source	14
	250

Conditions of the LP-Gas equipment that contributed to the origin of the fire or explosion, or contributed to the extent of the loss, were the following:

Leaking piping, fittings	50
Defective equipment	40
Broken piping, fittings	32
Open valves	30
Uncapped piping	15
Highway, railroad accident	13
Exposure to heat or fire	12
Leaking container	5
Pressure relief valve opened	4
Broken container	4
Miscellaneous known contributing conditions	11
No contributing conditions reported	34
	250

Ignition sources of the escaping gas were:

Heating, cooking equipment	49
Cigarettes, matches	37
Electrical equipment	31
Friction sparks	12
Exposed by another fire	10
Hot surfaces	4
Static electricity	2
Miscellaneous known ignition sources	17
Unknown ignition sources	88
	250

Residential Occupancies

Apartments

Lindale, Ga., Oct. 15, 1952, 1 killed

Tenants had occupied the combination apartment and store building for about two months when people in the store smelled gas. The operator's wife went outside to shut off the valve on the LP-Gas storage tank, and just as she had closed the valve, there was a terrific explosion which killed her and leveled the building.

About 40 minutes prior to the explosion, the LP-Gas storage tank, which had been empty all summer, had been filled. Sometime during the summer, a previous tenant had disconnected a gas-fired clothes dryer in the building and had left the ¾-inch line uncapped. Gas escaping from this open line probably had been ignited by an electrical spark from one of two small motors which were located near the pipe.

Forks, Wash., Sept. 25, 1954

While butane was being transferred from a delivery truck to a tank outside the 35-family, 3-story wooden apartment building, a failure of the hose or connections at the tank allowed gas under pressure to escape. The gas settled in the basement or in a kitchen, where it found an unknown source of ignition. The explosion and ensuing fire demolished the building, injuring five persons.

A hard-fought battle by six engine companies saved adjoining buildings, including the fire station, which was next door to the building involved. Loss was $100,000.

Groton, Conn., July 14, 1959

Although a housewife knew that her water heater was not operating properly on Sunday and that it was out all day Monday, she made no attempt to have the heater valves shut off. LP-Gas vapors concentrated in the basement until Tuesday morning, when the housewife asked her LP-Gas delivery man to relight the heater for her.

The delivery man first went to the basement and shut off the burner and pilot light valves, then returned to his truck to unload LP-Gas into a 500-gallon storage tank for the apartment building. This unloading operation took approximately one-half hour, during which time the delivery man felt the cellar would be cleared of any gas vapors that might be there.

Upon returning to the cellar, he struck a match to light the pilot light on the water heater, and there was an explosion which severly burned the delivery man and inflicted minor burns on a 2½-year-old boy in the apartment. Damage to the building was $2,700.

Investigation revealed that the water heater was 20 years old, had been purchased used, and installed in the apartment. The automatic safety shutoff was obsolete, and the right half of the draft screen was broken off and missing. The spuds in the main burner and pilot light had not been converted from natural gas to LP-Gas orifices and were much larger than recommended sizes.

Lindale, Ga., Oct. 15, 1952. The explosion that killed one person and leveled this apartment and store building involved gas that had been escaping into an apartment during the period between tenants. The outgoing tenant had removed a gas-fired dryer, leaving the ¾-inch pipe uncapped.

Miami, Fla., Oct. 2, 1959

The 4-story apartment building was served by two 500-gallon LP-Gas tanks having piping underground to meters outside, then entering the building above grade and rising through partitions to stoves and hot water heaters in the sixteen apartments. Although it was the usual practice to padlock closed valves downstream from meters when tenants removed their stoves, at this time the valves were closed but not padlocked.

One tenant, who had left, removed his stove, leaving an open ¾-inch line on which the valve had been closed at the meter but not locked. During the night someone apparently turned on the gas to this open line, and at about 4:00 A.M., tenants smelled gas. The odor of gas became so strong that several tenants left the building, but none thought to notify the manager or the fire department. At 7:05 A.M., an explosion occurred, causing severe damage to the apartments in the building. The ensuing fire was quickly extinguished by firemen. Loss was estimated to be $30,000.

A check of the gas meter to the apartment concerned showed that about 67 pounds of LP-Gas had leaked into the building through the partially opened valve. Fortunately, a considerable part of the gas was dissipated through open windows and doors.

Dormitories

Maidstone, Sask., June 22, 1954

Shortly after the official opening ceremony for the new nurses' home was over, someone smelled gas in the furnace room and reported it to the janitor. The janitor found that a valve on the high pressure side of a regulator was leaking, and in using a hammer to attempt repairs, he broke the valve. The valve was installed upside down for better access, and the tapered plug dropped out, allowing gas to escape into the room.

The janitor warned other occupants as he ran to get out of the building, but only a few of them got out before the gas was ignited. Fortunately, no one was injured in the explosion.

Schefferville, P. Q., Sept. 29, 1955

Living quarters for a construction crew at this recently opened iron ore site consisted of a central 8,000-square-foot wooden mess hall and kitchen building, flanked on two sides by rows of seven 1,680-square-foot wooden bunk houses. These and two similarly constructed office buildings were all connected to the mess hall by covered wooden passageways.

The fire originated in the open space beneath the kitchen floor and involved leaking propane gas. Propane for gas-fired hot water tanks directly above the location where the fire started was supplied from a bank of 18 cylinders outside the building. The ignition source was not determined, but the leak is attributed to the substandard practice of connecting the cylinders directly to the burners without an intervening pressure regulator.

Had an organized fire brigade and a reliable water supply for fire fighting been available, it is probable that the fire could have been checked before sweeping through the combustible and interconnected buildings. There was no fire brigade, and two portable pumps could not be started. Employees did discharge 84 foam and vaporizing liquid extinguishers, but these had no appreciable effect on fast spreading fires.

With the nearest water 2,000 feet away over rough terrain, the local volunteer fire department was severely handicapped but did manage to save parts of several buildings that were either on the windward side of the fire or were separated from the main group. Loss was estimated at $640,000.

Dwellings

Osceola, Ark., Feb., 1953

The occupants of a new house had just moved in and had set a washing machine over an uncapped LP-Gas pipe, which extended up through the kitchen floor. After the LP-Gas delivery man had filled the tank, he turned on the gas valve at the tank and went into the kitchen to light the pilot lights. Meanwhile, enough gas had escaped from the uncapped line in the kitchen to cause an explosion when he lit a match.

Stockham, Nebr., Aug. 28, 1954, 1 killed

A 6-year-old child was killed when a gas explosion wrecked the 1½-story wooden dwelling. The explosion occurred soon after the child's mother started to paint the basement walls, using a propane gas tank to supply pressure for the spray gun.

St. Simon Island, Ga., Feb. 22, 1955

Preparatory to painting the walls of his home, this homeowner removed LP-Gas-

St. Simon Island, Ga., Feb. 22, 1955. Before painting the interior walls, the owner of this home disconnected LP-Gas heaters and put wooden plugs in the ends of the pipes. During the night one of the plugs blew out. When the electric stove was turned on in the morning, the gas that had accumulated in the dwelling exploded.

fired unit heaters and closed the ends of the gas pipes with wooden plugs without shutting the gas off at the storage tanks outside. During the night one of the plugs blew out, allowing gas to escape. At 7:24 the next morning when the homeowner's wife turned on the electric stove in the kitchen to prepare breakfast, an explosion occurred that practically demolished the house and seriously injured the occupants.

Neenah, Wis., June 17, 1955

In making preparations for moving from the house the following day, the occupant disconnected a stove in the basement and attempted to seal the end of the tubing from the LP-Gas supply by mashing it against the basement wall with a hammer. This "seal" did not hold, however, and LP-Gas leaked from the tubing all afternoon and part of the night, until the gas was ignited by a spark from an electric pump or the flame of a water heater.

The resulting explosion severely injured the family of five who were in the dwelling at the time and blew out the outside walls of the house.

Duluth, Minn., Nov. 19, 1955, 3 killed

Instead of calling on trained and qualified men to make an LP-Gas installation in his home, the homeowner decided to do the work himself. Gas escaping from a loose connection in the kitchen ignited explosively on reaching the coal-burning furnace in the basement. Three of the four occupants asleep in second story bedrooms were suffocated in the ensuing fire. The $7,000 dwelling was destroyed.

Wolfeboro, N. H., Jan. 27, 1957

A new LP-Gas system which included a 1,000-gallon underground storage tank and 300 feet of 1-inch pipe was installed to provide gas service for two cottages. After a new furnace had been installed in one of the cottages, the pipeline was purged with LP-Gas from the storage tank into the basement of the cottage, instead of to the outside. The serviceman depended upon his sense of smell to tell him when the line was free of air and gas was coming through. His nose evidently did not function too well as a gas indicator, because when he started to light the pilot light on the furnace, gas in the basement exploded, burning the serviceman and damaging the cottage.

Boynton Beach, Fla., Dec. 5, 1957

When a tenant moved out of the house, he shut off the LP-Gas at the tank and removed the kitchen stove, which belonged to him but he did not cap the open pipe. The gas supplier contacted the new tenant and asked him if he wanted to use the LP-Gas, but the tenant said he did not. The supplier did not remove the system or check the piping, and when the weather turned cool, the tenant decided to turn on the space heater in the house. He turned on the gas at the tank, which allowed gas to flow not only to the space heater but also to the open pipe in the kitchen. When the tenant started to light the heater, an explosion of the gas from the open pipe severely burned him and badly damaged the house.

Palo Alto, Calif., May 20, 1958, 1 killed

A 5½-year-old girl was killed and her mother, father, brother, and two sisters were severely burned in an LP-Gas explosion in their attached 2-car garage. The force of the explosion wrecked their home and heavily damaged a home next door. Damage on the two homes totaled $30,000. Minor damage was also done to approximately 30 other houses in the area.

Prior to the explosion, the father of the victim had removed the pressure gage and shutoff valve from a 35-gallon LP-Gas tank in the garage, thinking the tank was empty. Instead of being empty, the tank was about one-fourth full. The gas escaped through a ½-inch orifice and was ignited by the pilot light of a furnace in the garage.

La Grange, Ga., Sept. 11, 1958

A "do-it-yourself" explosion occurred when a homeowner attempted to light a heater for which he had rigged up the piping himself. The contractor who had built the house had purchased a 20-pound cylinder of LP-Gas for the owner and was present at the time of the explosion. Both of these men said they did not smell the escaping gas because it was not properly odorized. A sample of the gas in the cylinder proved to be properly odorized.

Concord, N. H., Oct. 2, 1959

A homeowner and an LP-Gas serviceman were seriously burned when the serviceman evidently lit a match to check for a gas leak instead of using the brush and soap that he had with him for that purpose.

The owner of the private dwelling had smelled gas in the vicinity of a hot water heater in the basement and called for the serviceman, who shut off the gas at the heater and opened some windows to air out the basement. After waiting about one-half hour, both men entered the basement to check for leaks.

Oklahoma City, Okla., Oct. 10, 1959, 2 killed

Since the weather was still warm, the family had not connected their LP-Gas appliances after moving in a few days before. When the previous tenant moved out, he did not cap the lines from the LP-Gas tank when he disconnected his appliances. Somehow, unknown to the new arrivals, the LP-Gas valve on the tank was a quarter turn open, and gas was creeping into the house through three open pipe connections.

The husband and five children were in one room watching television. The mother had left the room and walked into the kitchen, where she started to light a cigarette. When she struck a match, there was an explosion which fatally burned her and one child and seriously burned the husband and the other four children.

Florin, Pa., March 31, 1960

The occupant of the dwelling had complained of a gas leak about two months be

Wide World

Neenah, Wis., June 17, 1955. This explosion occurred because the occupant attempted to seal off gas tubing by mashing it against a wall with a hammer.

Marshall Dussinger

Florin, Pa., March 31, 1960. A leak in piping beneath the kitchen floor was responsible for this fire. The piping carried LP-Gas from outdoor cylinders to the kitchen stove.

fore the fire. Servicemen had been to the home three times to repair leaks, but there was still an odor of gas in the house.

The mother and her three children were away from home for the night on March 31, and the father was alone in the house. He was awakened by a barking dog at 1:50 A.M. and smelled smoke. He started downstairs to investigate but was driven back by heavy smoke. Fortunately, he was able to escape by climbing out of a bedroom window to a porch roof and then jumping to the ground.

An LP-Gas line from the cylinders outside the house to the kitchen stove had developed a leak under the kitchen floor. The escaping gas had ignited from an unknown source and burned through the floor into the house.

Southwest Harbor, Me., Aug. 2, 1960

When the owner of a 1½-story wooden house lit a match to relight the water heater in his cellar, an explosion lifted the house off its foundation, blew apart the walls, toppled the chimney, and ripped out windows and doors. The owner and two other occupants of the house received burns and bruises.

A short time before the explosion, the owner's sister had complained of smelling gas in the house and the owner had gone to the cellar and shut off the LP-Gas-fired water heater. Laboratory tests of the heater assembly after the explosion revealed that a tee in the supply pipe to the heater had compression fittings which were not standard for that type of installation, and the tee was leaking at all three connections.

Arvin, Calif., Oct. 20, 1960, 1 killed

When the former occupants of the farm tenant dwelling moved out, they removed their LP-Gas heater from the living room, leaving the gas pipe uncapped. When the twelve new tenants moved in, a space heater was set in front of the open pipe. After all the furniture had been moved in and the kitchen range connected, the owner, assuming the heater in the living room had been connected, turned on the gas to the dwelling. Shortly thereafter, someone in the house struck a match, and the resulting explosion killed one person and seriously injured three others.

Washington, D. C., March 10, 1961

An electrician was trying to help his father replace some plumbing pipes; they tried to get a plumber's torch to work. After experiencing difficulty attaching the hose to the outlet of a propane bottle, they thought they should unscrew a plug on the shell of the container. When they did this, it blew off and gas poured forth. After they had made several unsuccessful attempts to replace the plug, the gas in the basement reached the lower explosive limit and two explosions ripped the house apart. The loss was $25,000.

Mobile Homes

Auburn, Mass., May 27, 1956, 1 killed

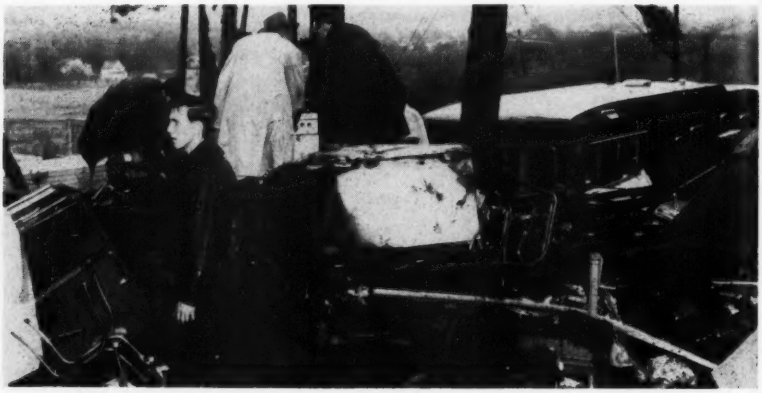
One of the two occupants of this mobile home was killed by an explosion of LP-Gas that demolished the trailer. The explosion occurred when the victim lit a match with which she intended to light a burner on the stove. Discovery of the oven control valve in the open position indicated that the explosion involved gas that had escaped into the trailer from the oven burner.

Rockmont, Wis., Aug. 27, 1960, 3 killed

LP-Gas leaking in the trailer, apparently from a cook stove, ignited explosively, killing the three occupants and sending parts of the trailer as far away as 500 feet. A neighbor heard the explosion, ran out of her house, and saw the trailer overturned and completely involved in fire. By the time firemen arrived from about 14 miles away, nothing could be done to save the residents of the trailer.

New Cumberland, Pa., Sept. 27, 1960, 1 killed

A house trailer in a trailer park exploded at 8:00 P.M. with such violence that only its



Ernest E. Wessell

Auburn, Mass., May 27, 1956. The control valve for the oven burner had been left in the open position in this mobile home. The occupant was killed by an LP-Gas explosion when she attempted to light the oven.

frame remained in the original location. LP-Gas was used for cooking, kerosene for heating, and candles for illumination. It is believed that a loose connection at the valve regulating the gas supply to the oven permitted gas to leak into the trailer and that the accumulation was touched off by the open flame of a lighted candle. The occupant is reported to have smelled the odor of gas for two hours before the incident.

The explosion and ensuing fire seriously damaged three other nearby trailers and a dwelling, killing one occupant of a trailer located about 22 feet away from the exploding unit. The victim's body was found in the debris following the demolition of one wall and the interior when the trailer was forced from its foundation. Exploding kerosene storage drums added to the intensity of the fire.

Motels

Lake Worth, Fla., Nov. 12, 1956, 2 killed

The two occupants of one of the living units at the motel were fatally burned in an explosion of LP-Gas that occurred in the morning when one of them struck a match to light the gas oven. The victims had rented the motel unit the previous evening, at which time it has been necessary to open an outside valve on the LP-Gas supply line so that the stove could be used. The occupants noted the odor of gas before going to bed but believed it to be the fresh paint.

Investigators discovered that the gas refrigerator had been disconnected from the fuel line for some unexplained reason, thus permitting gas to escape into the room during the night.

Arlington, Oreg., Dec. 8, 1959

After experiencing difficulties with a defective automatic shutoff valve on a water heater, the owner of the motel had capped the reset plunger button so that the unit would not shut off automatically in case the flame went out. The flame apparently did go out, and when the occupant of the motel activated a coin-operated clothes dryer in the same room, the escaping LP-Gas vapors were ignited explosively. The building, which housed a laundry room, shower room, lavatories, and storage area, was badly damaged, and the woman who had entered the building to use the dryer received first, second, and third degree burns.

Rooming House

Nevada City, Calif., Jan. 16, 1955

While under the influence of alcohol, an occupant of the rooming house attempted to light an LP-Gas heater in his room. Too much time passed between the time he opened the valve on the heater and when he lit the match. When the match was struck, an explosion occurred, blowing all the windows out of the rooming house and starting a fire that completely destroyed the property.

Public Assembly and School Occupancies

Amusement Places

Salisbury, N. C., March, 1957

The fire department responded to an alarm at the city armory where a circus was exhibiting. There was a small LP-Gas heater at one end of a wagon in which animals were kept. An attendant had left a small cylinder of LP-Gas near one of the cages, and a chimpanzee made a monkey of himself by reaching out of his cage, getting the cylinder, and opening the valve. The escaping gas was ignited by the heater in the wagon, and the chimp received severe burns on his hands.

The fire chief who reported this incident to NFPA said that it might be time to start a fire prevention school for animals. His idea was strengthened by a report from the State of Oregon concerning a fire caused by a monkey playing with matches.

near Sunnyside, Wash., Oct. 17, 1959, 1 killed

One of the customers at a gambling house on an Indian reservation had a small LP-Gas tank and heater with him. A small leak apparently developed around the connections on the tank, resulting in a small flash fire. The LP-Gas tank was wrapped with wet rags and set aside, where it continued to leak until a great deal of gas had escaped. When the gas ignited the second time, it was with explosive force, and one person was killed and ten injured.

C. L. Burkett

Salisbury, N. C., March, 1957. An LP-Gas heater was placed too near this chimpanzee's circus cage.

The 30-foot by 70-foot 1-story wooden building was of substandard construction and littered with rubbish. There was no fire protection — not even domestic water supply — and the building was a total loss.

Greensburg, Ohio, Sept. 23, 1960

Fire from an undetermined cause originated in or near a freezer in the first floor bar of a 60-foot by 160-foot, 1- and 2-story wooden amusement park building. A passer-by noticed the fire about 1 A.M. and immediately telephoned the fire department. Flames burned through a combustible fiberboard wall into the kitchen, from where they burst into the dance hall and spread along the plywood and combustible fiberboard ceiling.

The fire was being controlled when one of the seven LP-Gas cylinders located at the rear of the building ruptured violently. The released gas spread into the building and burned there as well as outside. Two of the remaining cylinders subsequently ruptured. These ruptures, plus the combustible interior finish of the unsprinklered building, contributed to the almost total loss.

A possible explanation of the cylinder ruptures is direct flame impingement on the vapor space with resulting excessive pressure buildup. As recommended in "How to Handle LP-Gas Vehicle Incidents," published in the August 1959 issue of NFPA *Firemen*, cylinders and other LP-Gas containers exposed by fire should, when possible, be kept cool with water to prevent such pressure buildup.

Church

Bennington, Vt., Aug. 8, 1961

The church organist had gone to the church to rehearse music for a funeral, and when she turned on the organ, a spark from the organ motor ignited an accumulation of propane gas which had entered the building from a broken line outside.

On Saturday, three days before the blast, a power shovel excavating for a parking lot

at the rear of the church had broken the gas supply line. The pipe was capped and the break was repaired the following Monday. After the explosion on Tuesday, investigation revealed another break in the pipe near the repaired section.

There was little or no fire subsequent to the blast, but damage to the church building was set at approximately $100,000. The organist was treated for burns on the face, left side, and left arm.

Restaurants

Kingston, Tenn., Aug. 20, 1954

While a delivery man was transferring LP-Gas from his tank truck to a storage tank behind a restaurant, some gas apparently was escaping from leaking connections. The gas soon found its way to the flame in a trash burner nearby and ignited explosively. Six persons were injured, the restaurant and an adjoining drug store were damaged, and the rear wall of the fire station across the alley was cracked from the force of the explosion.

Monticello, Utah, Aug. 13, 1956, 15 killed

Fifteen people in the 1-story concrete block building housing a restaurant were killed when an LP-Gas explosion that originated in the basement demolished the building. On the previous day a change-over had been made at the restaurant from LP-Gas to natural gas. After completing the natural gas installation, a workman shut off the LP-Gas supply by closing a valve at the 1,000-gallon outdoor tank. He then cut the LP-Gas supply line in the basement of the restaurant, neglecting to cap or plug the line.

The outdoor LP-Gas tank also supplied fuel for a gas hot water heater in a nearby apartment building. When the workman closed the valve at the tank, he, therefore (unknowingly), also shut off the supply to the hot water heater in the apartment. The explosion occurred after someone opened the valve at the tank, thereby allowing LP-Gas to escape into the restaurant basement from the cut pipe.

Investigation revealed that there was a tee on the low pressure side of the tank pressure regulator, one leg of which went to the restaurant, the other to the apartment, and that both legs were provided with manual valves. Had the valve on the leg to the restaurant been closed by the workman instead of the tank valve, the explosion would not have occurred.

Deseret News

Monticello, Utah, Aug. 13, 1956. Fifteen persons were killed when an LP-Gas explosion demolished the restaurant that stood on this site. Failure to cap or plug a cut LP-Gas supply line in the basement permitted gas to enter the building.

Kuhnsville, Pa., Sept. 27, 1958

A minor explosion and fire occurred in a concrete-block and wood-joisted addition to a steel diner. Upon arrival, the fire department evacuated the persistent patrons and employees and then extinguished the small basement fire. The odor of gas continued, and firemen made efforts to shut off the gas from the two 400-gallon underground LP-Gas tanks located approximately 50 feet from the diner. One tank was shut off, but a key could not be found to fit the other tank, and the gas supplier failed to respond to calls for a key.

Meanwhile, the assistant fire chief discovered a leak in a gas meter in the basement and attempted to ventilate the area. When he saw that these efforts were not effective, he ordered his men out of the building. Seconds after the last fire fighter came from the basement, a second explosion demolished the addition and moved the diner itself almost seven feet off its foundation.

Careful investigation later disclosed that a high pressure regulator had been operating erratically. This regulator was supposed to reduce the gas from tank pressure to 12 pounds. The 12-pound supply then entered another regulator which reduced the pressure to six ounces before it entered the meter. When the defective high-pressure regulator was dismantled, the diaphragm was found to be torn loose around the center. Investigating officers concluded that this regulator was allowing the gas to enter the meter at full tank pressure, thus causing a leak in the meter.

H. J. Gernerd

Kuhnsville, Pa., Sept. 27, 1958. A defective high pressure regulator allowed LP-Gas to enter a meter in the basement of this diner at tank pressure rather than at six ounces.

Crestview, Fla., Oct. 30, 1959

A licensed plumber was installing an LP-Gas-fired water heater in a building adjacent to a 20-foot by 40-foot, 1-story masonry, wood-joisted cafe. Somehow the gas line, which also served the cafe, was accidentally interconnected with the water line. The valve on the gas line was opened after the plumber had said everything was ready to go. The water heater made a hissing sound and would not light. Water seemed to be coming from the regulator on the 250-gallon LP-Gas tank, and the owner shut the valve but for some reason reopened it.

The gas entered the cafe through the toilet, reached an undetermined ignition source and exploded, injuring a 5-year-old occupant. The ensuing fire destroyed the cafe. A woman in a neighboring dwelling flushed her toilet and on hearing a strange racket in the tank, reflushed it. Gas that was thus released was ignited by a heater in the bedroom. The woman was badly burned. In another dwelling, a woman attempted to brush her teeth. When something smelling like gas came out of the faucet, she called to her father, who opened the faucet full force. The gas reached the pilot light on the bathroom heater. Both woman and father were injured.

School

Southmayd, Tex., Oct. 23, 1956, 2 killed

When a third grade teacher reported the odor of gas to the principal, the fire drill alarm was sounded, and all pupils and teachers immediately left the 2-story building. The custodian, accompanied by a high school student, then went into the building to find the leak and had just reached the second story when a gas explosion occurred. They were both killed.

It was learned that during the summer an LP-Gas-fired range and water heater had been removed from the second story of the school. The shutoff valve on the outlet serving the range was also removed and the ¾-inch outlet left uncapped.

On the morning of the explosion, in order that gas heaters in the school could be lighted for the first time, the shutoff valve on the outside storage tank was turned on (it had been shut off since the range was removed). When the tank valve was opened, gas escaped from the uncapped outlet in the second story.

Mercantile Occupancies

Auto Supplies Store

Big Stone Gap, Va., April 26, 1960

Two workmen were using a 100-pound cylinder of propane to supply a torch for sweating pipe joints during repairs to a water heater in the basement of the auto supply store. One of the workmen set the cylinder on the ground behind their truck and took the hose and torch down into the basement. The other workman set the cylinder on a hand cart and wheeled it closer to the basement steps, which were on the outside of the building. At this point the relief valve portion of the cylinder valve came apart, and the entire mechanism of the relief valve, including the retaining cap, blew away.

The gas, flowing freely from the open orifice on the cylinder valve, entered the basement and was ignited from a coal-fed boiler just inside the basement door. The workman who had been handling the cylinder outside the basement was critically burned. The other man, who managed to escape through an exit on the opposite side of the basement, received minor burns.

The relief device on the cylinder valve was described by the manufacturer as having a "tamper-proof" drive screw to hold the relief setting permanently in adjustment. The retaining cap that held the relief mechanism in place was supposed to have been secured by a pin through the side of the cap and the valve housing. Investigation disclosed no previous mishandling of the cylinder or valve. How the pin happened to come out and the cap became unscrewed could not be determined.

Compressed Gas Supplier

Mineola, N. Y., March 14, 1957

A child playing with matches set fire to paper under a wooden loading dock of a supplier of welding and other gases after the plant was closed for the day. Fire spread rapidly throughout the wooden dock and 4-story building, involving a number of LP-Gas cylinders. Several cylinders, exposed to burning gas from safety relief devices, ruptured and were hurled several hundred feet. Prompt work by the fire department prevented damage to a nearby 3-story wooden hotel and several office buildings. Trucks loaded with other fuel gas cylinders were driven from the premises by employees.

Drennan Photo Service

Mineola, N. Y., March 14, 1957. Several LP-Gas cylinders ruptured and rocketed hundreds of feet during fire at this compressed gas supplier. Failure to fence the premises made it possible for a child to play with matches under the loading dock where the fire started.

Electrical Appliance Store

Aiken, S. C., Jan. 27, 1953, 10 killed

Ten persons were killed, three 2-story buildings were wrecked, and two others were destroyed by ensuing fire when leaking LP-Gas exploded in the first story of one of the buildings. The explosion occurred when an employee of an electrical appliance store, on noting the odor of gas when he opened the store in the morning, turned on an electric fan to clear the store of gas.

Gas Appliance Stores

Beaufort, N. C., Feb. 15, 1952

Instead of waiting for the regular gas supplier's tank truck to come around, the owner of an LP-Gas appliance store decided to refill a 20-pound cylinder himself from a 100-pound cylinder. One of his assistants tried unsuccessfully to convince the manager that this should not be done indoors. Ignoring this advice, the manager connected the two cylinders together with a hose and started to make the transfer. During the transfer, one end of the hose came loose, and the escaping gas was ignited by a pilot light or burner flame in the store. The explosion seriously burned the manager and caused more than $100,000 damage to the store.

Belleville, Ont., Nov. 29, 1958

Burglars using an acetylene torch to crack the safe of this 30-foot by 60-foot 2-story frame gas appliance store were thought to have been scared off in such a hurry that they left the torch going. In any case, the fire was undetected until a 3:15 A.M. explosion blew out the front windows of the shop and awoke neighbors.

Responding fire fighters were able to operate on only three sides of the building due to a river in the rear. Twenty-five newly unloaded propane cylinders in front of the appliance store began to rupture due to heat from the fire. Fourteen separate explosions were counted. One cylinder rifled across the street and plowed into the veranda of a dwelling. The resulting fire was quickly extinguished. Another cylinder lopped a limb off a tree, and the top of another was found two blocks away.

The fire spread to a close-by builders' supply store and broke windows in a nearby bottling plant. A jeep drawing a brand-new, custom-made trailer was also destroyed. The trailer was at the appliance shop for installation of a gas stove.

Multiple Mercantile

San Francisco, Calif., April 1, 1953

Violation of a basic rule of NFPA Standard No. 58, which states that LP-Gas containers shall be gaged and charged only in the open or in special buildings, was responsible for an explosion and fire that severely damaged the 3-story brick, wood-joisted building. While a small tank was being filled with LP-Gas from a 30-gallon storage tank in the basement premises of a plumbing shop, the valve on the large tank "froze," and gas escaped into the basement. The plumber's employees, who were filling the tank, fled and were safely outside the building when the gas exploded about four minutes later. A pilot light on the first floor was a possible ignition source.

Englishtown, N. J., June 11, 1959

Failure to close the valves on LP-Gas service tanks outdoors contributed heavily to the spread of fire in a building which housed an auction sales business and 150 concessions. The fire of undetermined origin was discovered by a passer-by at about 2:20 A.M. Apparently no one thought to close the valves on four large LP-Gas tanks outside the building. These tanks contained gas for heating the building. The entire contents of the tanks were discharged into the building through piping broken during the fire. Many of the concessions in the building also had LP-Gas tanks, the contents of which added to the intensity of the fire.

Industrial Occupancies

Aircraft Assembly

Seattle, Wash., July 28, 1961

Four LP-Gas-fired heaters were used in an apparatus for heat testing jet engine accessories. LP-Gas entered a common header which supplied gas for each burner. The burners were manually lighted by pushing a button which started a 30-second purge period with a combustion air blower in operation, after which the burner was ignited by a spark plug. Trial for ignition was about ten seconds.

The operator went through the firing procedure to start up the heaters, which had not been used since the previous day. Judging from the lapse of time and indications of control lights, the heater appeared to purge normally, but when the gas came on, delayed ignition allowed enough gas to accumulate so that an explosion occurred in the fire box.

Investigation revealed that a microswitch which controlled the length of the purge cycle was not functioning properly. An improper automobile-type spark plug was being used as an igniter, and this spark plug had been painted over, affecting the contact.

Bakery

Etobicoke Twp., Ont., Sept. 21, 1954

An employee was seriously injured when a gas explosion destroyed a 70-foot by 9-foot plate-type oven, fired by liquefied petroleum gas. Since there were no flame failure safety devices on the pilot supervisory controls, it is believed that gas was introduced into the oven without being ignited. When the manual electric spark igniters were finally operated, a violent explosion resulted. Loss was $100,000.

Cereal Mill

Cedar Rapids, Iowa, Dec. 9, 1960

Liquefied petroleum gas was stored at this plant in 17,600-gallon and 30,000-gallon tanks as standby fuel for boilers during heavy community demands on the natural gas utility fuel supply normally used. A switchover to the standby supply had been made at 9:00 A.M. on December 8.

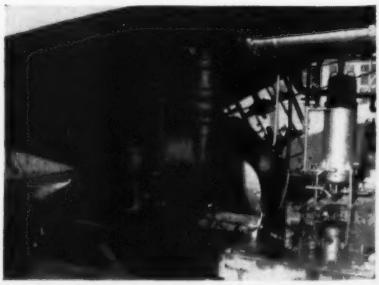
After the shaft of an LP-Gas-air mixing machine got out of line and damaged the shaft bearing, a gas leak occurred in the gas mixing building during the early morning of December 9. Sparks from an automatic electric call system transmitter ignited the gas accumulation. Force of the blast destroyed the building and ruptured a 4-inch high pressure natural gas line. A 2-inch LP-Gas line close to the outdoor storage tanks also broke.

Fire fighters responding to a promptly given alarm utilized six hose streams and had a manually operated water spray system over the storage tanks turned on in order to cool the tanks. Under this protection men were able to shut off valves controlling each of the gas supplies.

Dry Cleaning Plant

Englewood, N. J., April 25, 1954

An explosion in a brick and concrete vault 49.7 feet by 25 feet by 18 feet high in a dry cleaning plant demolished the vault, the cleaning plant, and an adjoining masonry, wood-joisted garage containing seven trucks. To remove dampness from the vault prior to storing clothing in it, a portable LP-Gas-fired heater had been placed in the vault on April 24. When an employee opened the vault on April 25, he smelled gas. When a



Cedar Rapids Fire Department

Cedar Rapids, Iowa, Dec. 9, 1960. Photo shows the remains of the LP-Gas-air mixing room at a cereal mill following an explosion that occurred on the day after the mixing machines were placed in operation. A damaged shaft bearing on the mixing machine allowed LP-Gas to leak into the mixing building.

match was struck, an explosion occurred that knocked out the walls of the vault, wrecked the adjoining garage, and severely injured the employee. Apparently, the heater had consumed all oxygen in the closed vault, after which unburned gas escaped. When the vault door was opened, an explosive gas-air mixture formed that was ignited by the match.

Garages

Elgin, Oreg., Nov. 9, 1953

A mechanic had brought a 39-gallon LP-Gas fuel tank of a truck, which he assumed to be empty, into the repair shop and set it down about 18 inches from a stove. He immediately went out of the shop to use the telephone, and while he was gone, the tank heated enough to open the pressure relief valve. The escaping vapors were ignited by the stove.

Ruidoso, N. M., June 22, 1955

At approximately 8:00 P.M., LP-Gas vapors escaping from leaking connections on an LP-Gas tank truck that had been brought into the garage for repairs were ignited from an unknown source. Following the initial explosion, the building was instantly involved in fire. Firemen responding to the telephoned alarm could do little more than protect exposures and allow the escaping gas to burn out at the relief valve on the tank truck.

Estevan, Sask., March 9, 1956

A truck carrying a 100-pound LP-Gas cylinder had been brought in for repairs. Upon leaving the garage, the unprotected valve on the cylinder struck the overhead garage door and was broken off. The truck driver heard the noise and got out of his truck to raise the electrically operated door a little higher before proceeding. He did not realize that the valve had been broken from the cylinder.

Another employee noticed what had happened and jumped into the truck to drive it out of the garage. At about the same time, the switch on the overhead door was tripped and apparently the sparks from the switch ignited the escaping gas. The man in the truck escaped injury, but the driver and another employee were badly burned about the face.

Belleville, Ill., July 24, 1958

Before doing some welding on the undercarriage of an 8,100-gallon LP-Gas transport trailer, repairmen decided to put some water in the bottom of the "empty" tank. They connected the 2-inch-high pressure discharge hose to a 2-inch water pipe. They did not realize that some LP-Gas remained in the tank. Since the water pressure was about 45 psi and the vapor pressure of the gas was about 100 psi, LP-Gas entered the city water mains.

The gas entered various buildings in the neighborhood through open connections to the water system (washing machines, toilets, etc.), and less than 10 minutes from the time the LP-Gas tank was connected to the water system an explosion occurred in the basement of a dwelling three blocks away. This was the first of a series of explosions that injured six people and blew out windows and doors of five dwellings and a store.

Enumclaw, Wash., Sept. 4, 1958

The heaters in the sales and service garage had been recently converted from LP-Gas to natural gas usage. The LP-Gas supplier was removing the LP-Gas tank from the rear of the building. While the tank was being loaded on his truck, a ¾-inch connection was broken off the tank. Escaping LP-Gas was ignited, apparently by an unknown source inside the building.

Fortunately, all of the occupants were able to flee from the building before the explosion. The entire building was involved in flames within a matter of seconds after the initial blast.

Meridian, Miss., Jan. 28, 1959

Repairs were in progress on a leaking LP-Gas tank truck in the sprinklered 40,000-square-foot 1-story garage when an explosion occurred that injured seven men, broke a 4-inch sprinkler riser, caused extensive structural damage, and started a fire. The explosion occurred when the leaking gas reached the pilot light on a water heater.

Fort Smith, Ark., March 5, 1959

The fuel tank of a delivery truck was filled with butane and brought inside the garage for the night. The warm air in the heated garage caused the pressure to rise in the fuel tank until the pressure relief valve opened, allowing LP-Gas vapors to escape into the building and to be ignited by an overhead room heater.

Three sprinklers opened and kept the fire under control until the fire department responded to the supervised sprinkler alarm.

Marshfield Fire Department

Marshfield, Wis., July 25, 1959. A leak developed in the piping of a 1,250-gallon LP-Gas tank truck, filled to 85 per cent of capacity, while in this garage for greasing and a brake check.

Marshfield, Wis., July 25, 1959

A 1,250-gallon LP-Gas tank truck filled to 85 per cent of capacity had been backed into the garage for greasing and a brake check. When a leak developed in a flexible rubber joint in the piping between the tank outlet and the meter compartment, four employees tried to close a valve ahead of the leak. Vapors spread throughout the garage. Realizing that an explosion was probable, the employees started to run; but before they could reach safety, an explosion occurred that leveled most of the 2,000 square foot 2-story brick, steel-framed building and severely burned the four men.

On arrival, firemen found the rubble ablaze and flames shooting upward 35 feet from relief valves on the truck's cargo tank. Hoses were used to cool the tank and to protect four aboveground LP-Gas storage tanks from 10 to 40 feet from the garage. None of the 28 partially filled 100-pound LP-Gas cylinders in the garage building ruptured, as their pressure relief valves functioned properly.

Ice Cream Plants

Dallas, Tex., June 27, 1961, 1 killed

An employee, readying trucks for the next day's sales, was loading a 100-pound LP-Gas cylinder onto one of the trucks. The cylinder was used to run the refrigeration machinery when the truck was not moving. The cylinder dropped and the valve was broken off. The gas poured into the building as employees stood around looking at the cylinder and trying to decide what to do, evidently unaware of the danger. The gas was ignited when it reached an undetermined ignition source. One man reported seeing a blue flame burn steadily through the gas on the floor until it reached the cylinder. There was a severe explosion which ripped the cylinder apart and blew bricks from the building wall all over the adjacent streets. One of the men was burned over 90 per cent of his body and died several days later. Three other men were severely burned. Loss was $80,000.

Cleveland, Ohio, July 20, 1961

The driver of a propane delivery tank truck had just completed filling a portable tank inside an ice cream company warehouse and garage building. He either forgot to turn off the valve on the delivery hose or inadvertently turned it back on after filling the portable tank. When he disconnected the hose from the tank, it began whipping around, spewing propane in all directions. Instead of turning off the valve, the driver panicked and ran out of the garage shouting for help.

The flame of a water heater apparently was the source of ignition. Two employees

received burns from the explosion, and damage to building and contents was estimated to be $69,500.

Industrial Laboratories

Columbus, Ohio, Jan. 11, 1957, 1 killed

Chemically pure propane at 145°F for use in experimental work on refrigeration control equipment was supplied from a cylinder mounted in a cabinet kept at 145°F. The cylinder had a volume of 968 cubic inches and according to ICC regulations should not contain more than 14.7 pounds of propane. The cylinder had a fusible plug but no relief valve or rupture disc.

On the morning of January 11, the practically empty cylinder was completely emptied and refilled from a full 100-pound cylinder by the following process. The small cylinder was packed in chipped dry ice to lower the temperature to minus 50°F and then filled until it had increased 19 pounds in weight. The cylinder was returned to the heated cabinet at about 11:30 A.M. At 1:30 P.M. the cylinder ruptured and in hurtling through the laboratory struck and killed an employee. Almost immediately an explosion of propane released from the cylinder severely damaged the building and injured four employees.

East Chicago, Ill., March 3, 1960, 4 killed

LP-Gas from the petroleum plant was usually brought to the laboratory in a 12-inch by 24-inch sample container. The LP-Gas in this case was brought into the 60-foot by 162-foot 2-story brick, concrete framed laboratory during the normal test procedures. Its sudden, unexplained rupture released the gas which was ignited by an operating bunsen burner. The explosion killed three male chemists, a female chemist and injured 5 others. The second story of the building was demolished. The ensuing fire was small and controlled rapidly. Loss was $500,000.

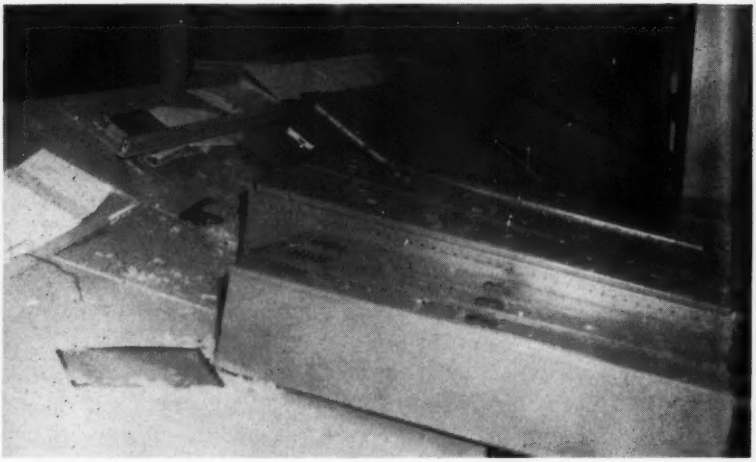
Petroleum Refineries

Bakersfield, Calif., July 21, 1952

Butane vapors spread over a 5-acre area when an earthquake toppled a butane storage tank from steel supporting girders, thereby breaking all connecting piping.

Dallas Fire Marshal

Dallas, Texas, June 27, 1961. An LP-Gas cylinder was dropped while being loaded on one of the refrigerated trucks at this ice cream plant. The valve broke off, allowing gas to escape into the building. One man was killed, three were severely injured and the building was wrecked.



Columbus, Ohio, Jan. 11, 1957. Rupture of a propane cylinder due to overfilling killed an employee at the research laboratory of a refrigeration control instrument manufacturer.

Ignition is believed to have occurred at electrical equipment. After a delay of 45 minutes until 90 high pressure stills were cut off, Bakersfield firemen were permitted to enter the refinery and use hose streams to cool equipment. When leaking butane storage tanks were cooled, the fire went out. Loss was $1,500,000.

Wilmington, Calif., July 22, 1955

Rupture of a 6-inch pipe carrying butane under 500-psi pressure from the process tower to the cooling tower was believed to have preceded an explosion and fire that damaged all outside processing equipment including towers, pressure vessels, and piping. Congestion of equipment and lack of water spray protection contributed to the $400,000 loss which would have been still greater but for two employees who shut valves at considerable danger to themselves.

Montreal East, P.Q., Jan. 8, 1957, 1 killed

During filling of a sphere, butane overflowed into the diked area in which three spheres were located. Some of the butane remained as a liquid, but, unknown to employees, a large vapor cloud also formed that spread over a large area. At approximately 4:15 A.M. the vapor cloud ignited, presumably from a heater in a service station 600 feet away. An intense fire broke out in the diked area around the spheres, and explosions occurred in pump houses and other buildings. One employee was fatally burned. When two of the spheres exploded, debris was thrown over a large area, and several tank fires were started.

The refinery fire brigade with the help of other private brigades and the public fire department brought the fire under control within 24 hours and had completed extinguishment in another 24 hours. Property damage and business interruption totaled $3,164,000.

Whiting, Ind., Jan. 29, 1957

Three interconnecting large pressure tanks in which propane from an alkylation unit depropanizer was stored were destroyed by a violent explosion that occurred when a valve was open to relieve pressure above the stored liquid propane. The explosion also occurred in the vent line which discharged into the refinery fuel-gas line. A high concentration of oxygen in the vapor space of the tanks was probably an important factor responsible for this explosion. No employees were killed but the explosion damaged the alkylation unit, destroyed several small buildings and started several fires at storage tanks, many of which were destroyed before the fire was controlled. The loss was $3,000,000.

Alma, Mich., Feb. 15, 1958, 1 killed

Overpressure of an "80-type" butane container caused it to rupture. The tank split

at the end as well as longitudinally. The released contents drifted across the refinery yard as a visible fog. The fog ignited when it reached a source of ignition in the powerhouse 350 feet away. A severe fire was caused which killed one man and burned four others.

The overpressure was apparently the result of inadequate venting capacity.

Ardmore, Okla., April 15, 1958

A propane mixture was being pumped from a storage tank to a tank car at the loading rack at an oil refinery when a flexible coupling between the pump and the storage tank failed. A workman noticed the vapors spraying out of the coupling, sounded the emergency whistle, and went through the vapors to attempt to close the valves. Before he reached the valves, the escaping vapors had found their way to a boiler house and ignited, blowing the employee into a ditch. The ensuing fire involved several buildings and storage tanks, including one 4,000-barrel tank of gasoline, which burned itself out. Damage was $100,000.

near McKittrict, Calif., May 28, 1959

A workman was starting to bleed water from a large horizontal LP-Gas storage tank when a 1-inch by 3-inch screwed pipe nipple failed at the threads, allowing the LP-Gas to escape through the 1-inch opening at about 100 psig. In a little more than a minute, the gas was ignited at a gas-fueled engine about 50 feet away. There were five other tanks nearby. The tank next to the tank with the broken connection was the first to fail. This occurred about ten minutes after the initial fire started. One head and about 15 feet of the shell of this tank traveled 2,250 feet. Within 35 minutes of the initial ignition, all six tanks had failed, some violently, and one with relatively small damage.

Of the six horizontal storage tanks of 10,000- to 26,000-gallon capacity, three contained butane, one propane, and two gasoline. Two of the butane tanks were almost full, but all of the others were less than one-quarter full. Apparently, the top dry shells became hot from flame impingement, softened, bulged, and ruptured. Miraculously, only two employees were injured.

Detroit, Mich., Feb. 24, 1960

Refinery workmen had installed a pump on an LP-Gas line leading to butane and propane receivers and had failed to tighten down all of the flange bolts. When the pump was placed in service, the propane leaked from the loose flange joint and was ignited by the open flame of a burnoff torch. Firemen allowed the spectacular blaze to burn under controlled conditions until the LP-Gas supply was shut off and the remainder of the gas in the lines was consumed. The employee who started the pump was injured, and damage to the plant was estimated at $133,000.

Bakersfield, Calif., Sept. 21, 1960

One head blew off a large horizontal natural gas blanketed caustic storage tank, presumably from overpressure caused by inadvertently introducing propane from a sour propane scrubber. The gas was ignited apparently by sparks from an electric panel board which was hit by the flying end of the tank. A piece of flying metal or other substance knocked loose a gage fitting and valve on another vessel about 100 feet away. This vessel contained butane which flowed to the ground where it was ignited by the original fire. This burning liquid flowed beneath four 10,000-gallon horizontal butane tanks.

The water spray system in the tank area was inadequate in both water delivery rate and design, and plant operators and the public fire department laid hose lines to cool the tanks. Fire was burning at the relief valves on all four butane tanks by the time the public fire department arrived, but the fires diminished rapidly as cooling water was applied. Under protection of water spray, the broken gage fitting was plugged and the original fire soon burned itself out. After the fire, it was found that one of the butane tanks was severely bulged on the bottom, this in opposition to the theory that vessels are usually self-protected below the liquid level line. Further inspection of the interior of the tank revealed a layer of rust and scale in the bottom of the tank about 3 feet wide and from 3 to 5 inches deep. This had served as an insulating blanket during the fire and allowed the tank plates to heat and bulge. The source of the residues was not known.

Printing Plant

Lennoxville, P.Q., May 28, 1954

A violent explosion of LP-Gas, followed by fire, destroyed a 2-story brick, wood-joisted printing plant.

Investigators concluded that the explosion occurred in the basement of the printing plant and involved propane gas that had leaked from a tee in ¼-inch copper tubing in the basement. The piping had conducted gas from outdoor cylinders to a press and to a strip-type casting machine. Automatic operation of an electrically driven sump pump provided the ignition source.

Two adjacent buildings were severely damaged by fire. One was ignited by sparks from the ensuing fire in the printing plant, the other by burning propane from a cylinder that had been blown against it by the explosion.

Steel Fabricating Plants

Louisville, Ohio, Aug. 28, 1953

The cause of the fire was not known, but its progress was well marked by periodic explosions of cans of paint and thinner and small cylinders of LP-Gas. The plant manufactured gas conversion burners and small gas and oil stoves for trailers. The fire had been discovered by a passer-by and had spread considerably by the time firemen arrived.

Although fire fighting inside the building would have been more effective during the early stages of the fire, firemen were reluctant to enter because of the exploding small LP-Gas cylinders which were attached to small stove units. As these cylinders exploded from exposure to the fire, they threw burning debris around the building. Adding to the anxiety of the firemen was a barrel of paint thinner which was outside the building and exposed to the fire. An inadequate water supply from the small mains made the fire fighting even more hazardous. Loss was $93,000.

Milwaukee, Wis., Nov. 9, 1955

A 60-foot-high LP-Gas fueled, special atmosphere furnace used for annealing steel blanks was badly damaged by a gas explosion in the furnace. The explosion occurred when air entered through the furnace charging door and formed an explosive mixture with the combustible gas atmosphere in the furnace. The furnace had been equipped with a flame curtain at the charging door to prevent air from entering the furnace during charging operations. The flame curtain had been removed to facilitate installation of a vestibule at the charging door and had not been reinstalled at the completion of the work. Property damage was $100,000.

Streator, Ill., Feb. 29, 1956

An employee who was working on an LP-Gas-fired heater in an office was reportedly trying to remove condensation from the device when, somehow, escaping gas ignited explosively. The employee suffered burns on his face and arms, and the office was completely destroyed by the ensuing fire. A paint room adjoining the involved office was saved by a 20-inch-thick concrete block wall which separated the two areas. Loss was $37,000.

Newton Falls, Ohio, Feb. 18, 1958

About four years previous to the fire, the plant furnaces had been converted from LP-Gas to natural-gas usage. The LP-Gas vaporizing and mixing equipment had been idle during all these years until the natural gas supplier ordered temporary complete curtailment of gas service to the plant during the very cold weather. Workmen readied the standby LP-Gas equipment for service and had the furnaces operating on LP-Gas within 14 hours. Early the next morning flames were seen coming from the building which housed the LP-Gas equipment, and the public fire department was notified. A representative of the LP-Gas supplier responded to a call from the plant and shut off the supply. He also warned firemen not to extinguish the flames until the remaining fuel in the extensive piping was consumed. Flames continued at several fittings over the equipment and piping for about an hour. The equipment had not been pressure-tested for tightness before being activated.

LP-Gas Filling and Distribution Plants

Gloversville, N. Y., April 12, 1952

Storage of LP-Gas cylinders above an unventilated basement (contrary to provisions of NFPA Standard No. 58) resulted in an explosion that wrecked the 2-story wooden building and broke windows in exposures. Gas from a leaking cylinder of propane on the first floor is believed to have collected in the basement, where it was ignited when the oil burner started.

Greensboro, Ala., July 26, 1952, 3 killed

While butane was being transferred from a transport tank to a bulk plant storage tank, the delivery hose broke. Escaping gas spread to a nearby dwelling, where it ignited at a cook stove. Fire flashing through the gas fatally burned three persons in the dwelling and spread to the truck, storage tank, and a lumber yard. An excess flow valve is reported to have failed, and the truck driver was unable to close valves before the truck and storage tank were enveloped in fire.

Augusta, Maine, April 6, 1953

LP-Gas cylinders are frequently stored on platforms adjoining or adjacent to LP-Gas distributing plants. At this particular plant, approximately 700 100-pound cylinders and 200 20-pound cylinders were stored on a loading platform and on the adjacent ground. The fire originated in the charging room, and although discovered promptly by the plant manager, spread so rapidly that the manager was driven from the building after discharging a 15-pound dry chemical extinguisher.

Kennebec Journal

Augusta, Maine, April 6, 1953. Originating in the cylinder charging room, fire spread to the adjoining cylinder storage area. In most instances, relief valves functioned properly, but a few cases, cylinders ruptured.

Heat caused relief valves to open on cylinders stored outside, resulting in an intense fire in the cylinder storage area before firemen arrived. In most instances, the relief valves functioned properly, but in a few cases where apparently the cylinder walls above the liquid level were heated sufficiently before the valves could operate, the cylinders ruptured. The threat of explosions greatly hindered fire fighting.

near Miami, Fla., June 7, 1953

A faulty neon sign on a 1-story masonry, wood-joisted bottling plant was the probable cause of fire that spread along a wood canopy above a platform of full cylinders causing relief valves on many cylinders to open; in some instances the cylinders ruptured. Fire fed by escaping gas entered the bottling building and, on reaching the pump room, ruptured a 3-inch LP-Gas pipe from which gas escaped and burned until the excess flow valve operated. Gas escaped and burned at a manhole gasket on an 18,000 gallon storage tank located only 7 feet from the bottling building, and fire also spread to a 1-story metalclad building on adjoining property and 10 feet from the bottling plant.

Tecumseh, Mich., Aug. 12, 1953

An employee was charging a small cylinder with LP-Gas when the transfer hose came loose and lashed about, spewing LP-Gas. Evidently, the connection on the loose end of the hose struck the cylinder, causing a friction spark which ignited the escaping gas. The fire spread throughout a wooden loading dock and involved a stock of 100-pound containers of LP-Gas. About a dozen of these cylinders failed during the fire, some of them rocketing to locations outside the plant. The fire was quickly brought under control, however, and the loss was set at $5,000.

Miami Fire Prevention Bureau

Near Miami, Fla., June 8, 1953. Originating at a neon sign, fire spread along a wooden canopy over a platform on which LP-Gas cylinders were stored. Relief valves on many cylinders opened. Some cylinders ruptured. On entering the pump room, fire caused a 3-inch LP-Gas pipe to rupture.

Atlanta, Ga., Jan. 4, 1954

LP-Gas, apparently leaking from transfer connections while a tank truck was being loaded from a 21,000-gallon storage tank, ignited from an unknown source. The flames quickly opened relief valves on nearby containers of LP-Gas, which added to the intensity of the fire. Several small containers ruptured, and three trucks and an automobile were destroyed. Firemen used hose streams to cool the 21,000-gallon and 16,000-gallon storage tanks and four 10,000-gallon tank cars in the fire area. As soon as a man was able to approach the storage tanks under cover of a hose stream and shut off the valves, the flames went out.

Compton, Ky., Jan. 15, 1954

Substandard installation of a 1,000-gallon aboveground LP-Gas storage container was responsible for the explosion and fire that damaged several buildings and burned five boys in a parked automobile. The explosion occurred about 15 minutes after the container fell from its unstable, concrete block foundation. The discharge pipe connection at the 2-inch container outlet was broken, and since no excess flow valve was installed, the contents of the container escaped, vaporized, and spread over a wide area. The explosion occurred when the vapors reached an ignition source in a 2-story wooden store.

Fredericksburg, Va., April 10, 1954

Failure to provide for expansion and contraction of liquid-carrying pipe between two aboveground 30,000-gallon LP-Gas tanks resulted in a nipple failure beneath one of the tanks. Leaking gas spread into the gas plant 6 feet away where it exploded on reaching an open flame. The ensuing fire burned off part of the wood roof of the gas plant. Gas burned at the leaking nipple until the leak became severe enough to cause the excess flow valve to function, after which the fire at the tank went out. During the fire, hose streams were used efficiently to cool both tanks.

Lakeport, Calif., July 13, 1954, 4 killed

The driver of an LP-Gas delivery truck had filled his truck tanks from a storage tank and apparently started to drive off without disconnecting the transfer and vent lines. The 2-inch filling line was pulled out of the threads at the truck header, allowing LP-Gas to escape and flood the area with LP-Gas vapors. Workmen were unable to shut off the flow of gas, and the vapors ignited from an unknown source about ten minutes after the accident. Four persons in the area were fatally burned. Fortunately, most of the occupants of nearby resort cabins had fled before the gas cloud ignited.

Fire flashed over the entire area, setting two dwellings and an office building on fire and starting a fire on top of an LP-Gas storage tank, where a vapor return connection happened to be cracked. The fire on top of this tank eventually overheated the metal and caused the tank to rupture. Firemen allowed the LP-Gas in an adjoining tank to burn out through the vent in which the neoprene disc burned out. The third tank in the bulk plant was not damaged.

near Goulding, Fla., Oct. 1, 1955

The day before the fire, the owner of the LP-Gas bulk station had removed the gasket from a transfer line connection and loaned it to an employee for use on a transport tank truck. The owner replaced the connection with an older model.

On the day of the fire, another employee noticed that the old connection was on the line and replaced it with the original, which had no gasket. When he turned on the valve, he saw that the gasket was missing and shut it off immediately. After cutting a new rubber gasket, the employee placed it in the connection and started the transfer pump motor.

As soon as the motor started, there was a mild explosion. The fire quickly involved the pump enclosure and the tank truck and spread to a nearby warehouse. The pump enclosure and warehouse were totally destroyed, and the tank truck was severely damaged. The employee received first and second degree burns.

near Elkhart, Ind., Oct. 14, 1955, 1 killed

Between 5:00 P.M. and 7:00 A.M., when this station was unattended, truck drivers were permitted to fuel their vehicles. At 5:30 A.M. a truck at the station backed into and snapped the 1½-inch LP-Gas fill line. Since the shutoff valve for the fill line was located in a fenced and locked pump house, the gas continued to escape, forming a low-lying cloud that spread over the adjacent highway and into a paint shop.

The driver of a truck going along the road stopped his vehicle in the cloud, possibly because of the poor visibility, and is believed to have tried to light a warning flare. Fire flashed through the vapor cloud, inflicting fatal burns on the driver and enveloping the adjacent paint shop.

Hoopa, Calif., Dec. 14, 1955

An employee of an LP-Gas distributing company failed to disconnect the transfer hose after having loaded his tank truck. When he started to drive away, the hose broke at the connection. The escaping LP-Gas formed a vapor cloud about three feet deep over an area of approximately 300 square yards while the driver of the tank truck endeavored to shut off pilot lights on water heaters and stoves in the nearby dwellings. His efforts were in vain, however, and the vapors ignited from an unknown source, injuring several persons and setting fire to dwellings in the immediate area.

Gary, Ind., June 4, 1956

Fire that destroyed the pump house and two trucks and burned the outside of a wooden building 75 feet away broke out when LP-Gas escaped from a flexible hose that had just been used to fill a tank truck with 1,200 gallons of LP-Gas. The hose appears to have been pulled apart when the truck started away, although reports do not indicate whether it got snarled in the truck or had not been disconnected.

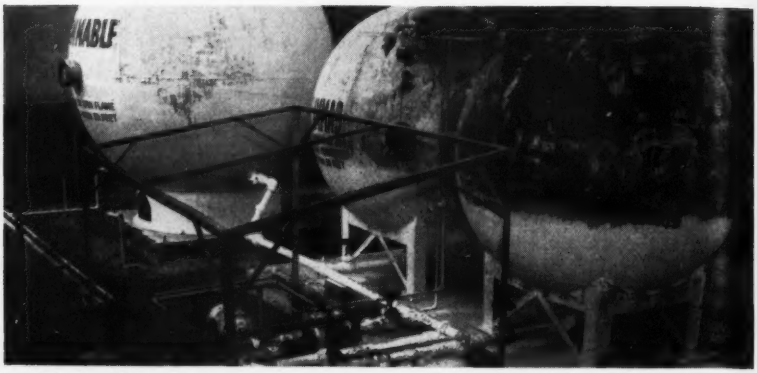
Gas burned at relief valves on the tank trucks and exposed a 30,000-gallon above-ground storage tank. The only explosions involved several of the 100-pound cylinders at the plant.

Cottage Grove, Oreg., Oct. 22, 1956

Twelve fire fighters and twelve civilians were hospitalized when a 15,000-gallon LP-Gas tank ruptured during fire fighting operations at an LP-Gas bulk plant. The original fire and explosion had occurred in a building housing a vaporizer and boilers and had spread to the area beneath the large storage tank. The source of the gas causing the initial explosion is unknown, but it is thought to have been from leaking fittings or a broken sight glass on a columnar gage. Ignition probably was from the boiler.

When the first fire companies arrived, they found the west wall blown out of the vaporizer building and fire burning fiercely under the storage tank and at the vents of the tank. Firemen extinguished the fire in the vaporizer building, but the fire seemed to intensify under the large tank, possibly because of gasket failure on a line that connected to the bottom of the tank in the fire area. About 20 minutes after the first alarm, the 15,000-gallon LP-Gas tank ruptured violently, incapacitating one fire truck and setting fire to three houses nearby. Of the eleven firemen on the fire ground, only four could still use their hands after the blast. They called by radio for mutual aid and ambulances.

Investigation revealed that nonferrous risers and caps on the tank safety relief devices had melted and had almost completely sealed off the discharge from the valves. This probably allowed enough pressure to build up inside the tank to cause it to rupture.



Los Angeles Fire Department

Van Nuys, Calif., June 24, 1957. These three storage tanks were exposed by fire that broke out when a 2-inch hose broke while LP-Gas was being transferred from a tank truck to the storage tanks. Pressure relief devices on the spherical tanks functioned properly.

Albany, Oreg., April 22, 1957

At 5:40 P.M., shortly after this 40-foot by 50-foot 1-story wooden building had been closed for the night, an LP-Gas explosion extensively damaged the shop, office, and appliance display areas. It is believed that the explosion originated in the shop area and involved gas that escaped from an open gas cock at a work bench outlet.

At the work bench there were two small lines controlled by a single valve. Each of the two lines had a valve at the end. These lines were used to test repaired gas appliances. One employee had used one of the lines and had shut off the gas at the common valve, but had failed to shut off the cock at the end of the line he had been using. Later in the day, another employee used the other line, opening the common valve. He was unaware that LP-Gas was escaping from the open cock on the previously used line. Instead of turning off the gas at the common valve, this employee closed only the cock at the end of the line he was using, thus allowing LP-Gas to continue to flow freely from the open line. The source of ignition probably was the pilot light on a nearby room heater.

Van Nuys, Calif., June 24, 1957

A tank truck driver had been unloading his trailer for about 40 minutes into three spherical storage tanks when his 2-inch transfer hose burst, allowing LP-Gas to escape from the opening under 125 psi pressure. The driver raced to the public highway, about 175 feet away, and telephoned the fire department. At about the same time, the escaping vapors ignited from an unknown source. Approximately 7,500 gallons of LP-Gas burned at 14 openings in the bulk plant before the extinguishment was completed. These torches were caused by 6 pipeline and hose failures, 4 melted brass and bronze valves, and 4 operating relief devices. The internal excess flow valve in the truck cargo tank was wired open.

Fortunately, the unloading pump operated all during the fire and prevented a heavy backflow of LP-Gas from the tanks to the broken unloading manifold. This was a reversible, positive displacement gear pump, and although it was pumping from the truck unloading manifold to the storage tanks, the 0.004 housing clearance could leak back as much as 80 gallons a minute because of the differential pressure between the tanks and the open-end line.

Jackson, Miss., Sept. 4, 1957

A workman was unloading LP-Gas from a tank truck to a storage tank when the transfer hose burst. When a workman across the street noticed what had happened, he went to move his automobile from where it was parked near the LP-Gas plant storage yard. When he started the car, the escaping vapors ignited, forcing him to abandon the vehicle.

Responding fire fighters found the tank truck ablaze at the broken hose and at the relief valve. They immediately set up hose lines and set about to cool the nearby stor-

age tanks. They allowed the escaping gas from the tank truck to burn itself out for about 8½ hours.

Salem, Oreg., Sept. 22, 1957

Answering a passer-by's alarm at 3:50 A.M., firemen found fire out of control in a wood-framed, metal-clad warehouse and on an adjoining covered platform on which an automatic gas-fired water heater for a vaporizer was located. An adjacent pump and valve house was also in flames, and LP-Gas was escaping from relief valves on the liquid supply lines from storage tanks to the valve and pump house and from valves inside the house where neoprene packing and valve seats had failed.

Recognizing that the first principle to be followed when fighting a fire involving escaping gas is to stop the escape of gas before extinguishing the fire, the fire chief ordered some of his spray-nozzle-equipped hose lines used to cool three exposed aboveground LP-Gas storage tanks. The remainder were used to cool the area around the pump and valve houses. Eventually, it was possible for firemen under cover of water spray to reach and close valves on liquid supply lines. With escape of gas thereby stopped, firemen then concentrated on the main fire at the warehouse and loading platform.

Sacramento (Arcade Fire District), Calif., Oct 24, 1957, 1 killed

The driver of a 3,500-gallon LP-Gas tank truck with 4,500-gallon trailer had started unloading his trailer to a 30,000-gallon storage tank. When he attempted to connect an unloading line to the truck tank, he found that it would not reach. Without shutting off or disconnecting the line to the trailer, the driver moved the truck and trailer forward so the hose would reach the unloading connections. In moving the vehicle, the hose to the trailer tightened against the tire on the trailer, and the rotation of the tire pulled the hose under the tire, squeezing the hose and causing it to break off at the coupling. This action by the truck driver was taken in violation of safety rules and regulations, which require that brakes be set and wheels blocked on both tank truck and trailer before making connections.

Very soon after the hose failed, the escaping LP-Gas ignited from an unknown source. The explosion and ensuing fire ignited three house trailers on an adjacent lot, fatally burning an occupant of one house trailer and injuring his wife and two children. The truck driver also received serious burns.

Pre-fire planning and inspections by the local fire department paid off at this spectacular blaze. Responding firemen were familiar with the plant layout, and they knew how to handle LP-Gas fires. The first companies to arrive sent a call for additional help, checked the burning house trailers for occupants, and set up hose streams to cover each end of the burning tank truck and trailer. The fire chief ordered his men to direct the hose streams for cooling purposes

Arcade Fire District

Sacramento, Calif., Oct. 24, 1957. The value of prefire planning was demonstrated at the LP-Gas tank truck fire adjacent to a trailer park.

on the truck, trailer, and storage tank, cautioning the men not to extinguish the flames from the escaping gas. The fire centered around the truck and trailer and was fed by the LP-Gas escaping from the broken hose and from relief valves. The truck's fuel, tires, and other combustible parts were also burning. As the blazes from the latter sources were extinguished and the tanks began to cool, the flames from the relief valves gradually reduced to controlled burning.

Firemen were then able to approach the storage tank and piping, under cover of a hose stream, and close all valves. This stopped the flow of LP-Gas to the broken transfer hose under the truck tire, and that flame went out. By this time the trailer was cooled enough so that its relief valve closed. This left only the flame at the tank truck relief valve, which soon ceased, and a small flame under the truck, which was allowed to burn out.

The LP-Gas remaining in the trailer was transferred to the storage tank, and the vapors remaining in the tank truck and trailer were burned off under controlled conditions until both tanks were at atmospheric pressure. Fire fighters picked up and returned to quarters 40 hours and 34 minutes after the first alarm had been received. There was no one injured other than those in the initial blast, and the intense fire had been confined primarily to the point of origin.

A motion picture film, "LP-Gas Fire Control," based upon the fire fighting operations at this fire, is available from the NFPA. This is an outstanding training film on the subject of fighting LP-Gas fires.

Oxford, Pa., April 3, 1958

Workmen were making repairs on a tank truck inside a storage warehouse for bottled gas and equipment. When the driver started the truck to see if the pump was working properly, an accumulation of escaping LP-Gas was ignited by the truck's ignition.

Kimball, Nebr., July 10, 1958

A driver had just started to pump LP-Gas into his tank truck when he heard a small explosion in the pump house and saw flames run up the filler hose to the rear of his truck. The flame soon caused the 2-inch hose to fail and an intense LP-Gas fire was going. The driver immediately left the area and telephoned the fire department.

The main control valves for one 12,500-gallon tank and eleven 1,100-gallon tanks were located in or close to the burning pump house. Firemen in protective clothing and under protection of hose streams entered the fire area and shut off each individual tank. Overhead 2,300- and 2,400-volt electric wires, one of which burned in two during the fire, gave fire fighters additional cause for concern. A total of about 5,000 gallons of LP-Gas was consumed by the fire, and the pump house, a storage building, and the tank truck were destroyed.

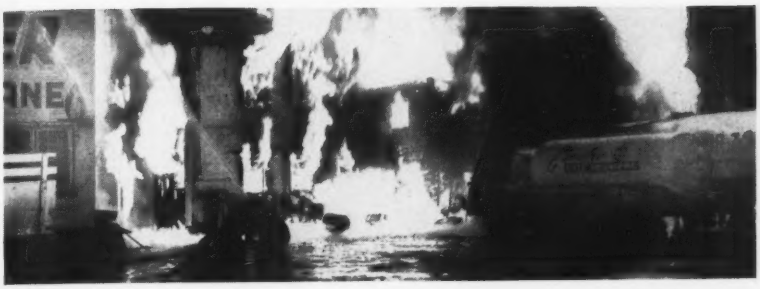
This LP-Gas distribution plant was about 20 years old, and the equipment in it was in generally poor condition. It is thought that the fire was caused by gas that escaped from the faulty pump.

Brinkley, Ark., March 12, 1959, 1 killed

When a butane delivery truck driver was readjusting the position of his truck, he apparently forgot to disconnect the fill hose. The hose was pulled full length and put a severe bend in the loading manifold before the hose broke. The manually controlled valves on both tank and truck were found open after the fire. The excess flow valve on the tank did not close. It is thought that the friction loss from the piping com-

United Press International

Brinkley, Ark., March 12, 1959. Failure of an excess flow valve to close allowed the contents of a large LP-Gas storage tank to flow into the fire area. Three large LP-Gas storage tanks subsequently ruptured.



R. L. Gendron

Montreal, P. Q., Jan. 25, 1960. Six parked LP-Gas tank trucks were seriously exposed by fire that originated in the cylinder painting building. The five that were parked headed out were driven to safety.

plex reduced the flow and kept it below the operating rate of the excess flow valve. The ignition of this large flow of butane gas was thought to have occurred from the motor of the delivery truck. The truck driver died in the hospital from third degree burns.

The ⅓-of-a-city-block area in which this incident occurred was congested with three gasoline bulk plants, six buildings, the butane bulk plant, two butane railroad tank cars, and 21 trucks and cars.

During the early stages, a 6,431-gallon propane tank and one of the 15,000-gallon propane tanks ruptured, due to overheating of their shell sections. Then one of the two large 16,000-gallon butane tanks ruptured, sending its contents of 13,000 gallons of burning butane flaming over 1,200 feet into the air. The overheated tank broke into three pieces, two remaining nearby. The other, a head and 1½ courses of shell section, was propelled violently forward through an unoccupied fish market and into the town's main street. The fish market was destroyed. After this explosion, fire fighters and equipment in addition to the two towns called, arrived voluntarily from ten towns.

As a result of the explosion, the end of one building was blown out, one building was smashed flat, one railroad tank car was blown off its tracks, and one transport trailer was blown upside down. Good fire department operation succeeded in saving three buildings, the three nearby gasoline bulk plants, and thirteen vehicles.

Max Meadows, Va., July 14, 1959

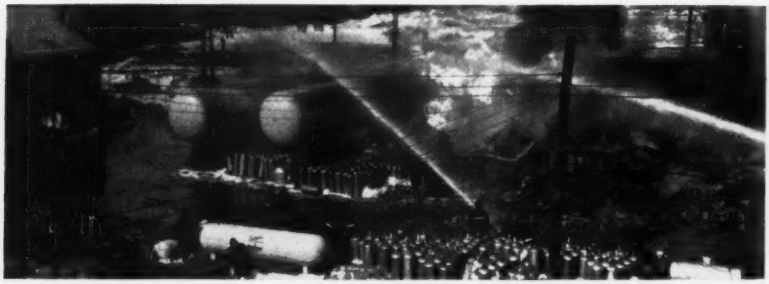
An LP-Gas hose ruptured while an employee was filling a 2,000-gallon twin barrel LP-Gas delivery truck from an 18,000-gallon storage tank at a bulk plant. The released vapors ignited and involved the tank truck. Although he was badly burned, the employee immediately closed a valve in the truck liquid loading line and escaped from the fire area. He then called the Wytheville Fire Department, which responded about 15 minutes later. By the time the fire fighters arrived, the excess flow check valves on all LP-Gas lines had closed and the gas flow was reduced to that escaping through the 0.04-inch pressure equalizing opening. However, fire from the vehicle tires was intense enough to cause the tank truck safety relief valve to operate.

Not recognizing the significance of the relief valve operation, the fire fighters feared an explosion and withdrew their equipment. Spectators were moved back to a safe distance. An effort was made to locate the plant owners, who were finally reached about 90 miles away. The owners arrived on the scene about three hours later; and after making certain that all LP-Gas piping, the main storage tank, and other equipment were not involved, they asked the fire fighters to move in and put out the truck tire fire. This was accomplished in about 10 minutes, and the safety relief valves on the tank truck ceased to operate.

Fire damage was confined to the tank truck and scorched paint on the pump house door and railroad tank car on the unloading track. No damage occurred to plant buildings, bulk plant piping, or storage tanks.

Montreal, P.Q., Jan. 25, 1960

Originating in the unsprinklered 2-story masonry, wood-joisted cylinder paint shop, fire spread rapidly out of control when barrels of alcohol that were stored in this build-



Lachine, P. Q., March 14, 1960. Although flames impinged on the two large storage tanks shown, correct use of hose streams to bathe the tanks with water prevented their rupture.

ing ruptured. Six filled LP-Gas tank trucks that were parked a few feet from the burning building were seriously exposed. Three were driven to safety before becoming involved, but the others could not be moved before safety relief valves on cargo tanks opened and escaping gas ignited. Hose streams were used to cool the cargo tanks. Under cover of water from four hoses, employees managed to uncouple trailers from two tractor-trailer units and drive the tractors to safety. The other tractor was headed in and could not be saved.

The fire was extinguished in two hours. On the following day approximately 10,000 gallons of LP-Gas was pumped out of the cargo tanks that were exposed throughout the fire. With the exception of the one tractor that was destroyed, all tractors and semi-trailers were checked and back in service within two weeks.

Lachine, P. Q., March 14, 1960, 2 killed

An explosion of undetermined cause blew apart a concrete block cylinder filling building in this bulk LP-Gas plant. Two men were killed and three were injured.

Responding fire fighters found flames heavily exposing and directly impinging on the two large plant storage tanks and one of the two railway cars. The fire chief immediately issued the correct orders to bathe the tanks and car with heavy hose streams. This kept the metal cool enough so it did not fail under the extreme heat. The exposing fires were then attacked and extinguished.

Defiance, Ohio, Sept. 13, 1960

After filling several 100-pound cylinders with liquefied petroleum gas from a nearby 30,000-gallon storage tank, an employee shut off the pump. At that time, an accumulation of leaking gas was touched off by an ignition source. A neighbor heard the explosion and called the fire department.

The ensuing fire involved the filling building and was confined to it. Gas continued to feed the fire through the 1-inch line because the excess flow valve failed to close. The 3-inch excess flow valve located at the tank did not close, as the flow through the 1-inch line was not at a sufficient rate to operate the valve.

Fire department hose streams and an aerial ladder gun were used to cool the storage tank only 14 feet from the burning shed. A company employee closed the discharge valve on the tank while water fog streams were played on him for protection, and this action completed extinguishment of the fire.

Los Angeles, Calif., Dec. 21, 1960, 2 killed

Two men were unloading a 388-gallon LP-Gas tank from a boom-equipped flat-bed truck. The unit was being lifted by both the truck boom and a yard boom when the yard boom connection broke, allowing the tank to fall against the back of the truck. The impact knocked the valve and valve cover off the tank, and LP-Gas freely escaped from the 1¼-inch opening. The gas was ignited by an unknown source before the two men had a chance to escape. They were fatally burned.

Bayonne, N. J., Dec. 28, 1960

A truck driver spotted a twin tank liquefied petroleum gas semitrailer with 4,500 gallons of propane unhooked at an unloading platform, and he left with the towing unit to do other hauling. Following the

Ray Watkins

Perry, Mich., June 2, 1961. Fearing an explosion, fire fighters and employees delayed attack almost four hours.

unloading of the tanks, plant personnel shut off the unloading pump and its suction valve. However, valves on the "empty" tanks were not closed nor were hoses disconnected when unloading was completed between 5 and 6 P.M.

When another loaded transport vehicle arrived at 11 P.M., its tank semitrailer was parked so that the truck tractor could relocate the "empty" semitrailer. During engagement of the fifth wheel, the hoses from the "empty" tank that had not been disconnected were broken. It is reported that liquid came out at the rear trailer connection, undoubtedly due to a low atmospheric temperature (25°F) which caused vapors in the "empty" tank to condense. Ignition for the intense fire that followed could have come from a unit heater in a nearby office. From 150 to 200, 100-pound storage cylinders stored nearby became involved in the fire. Some ruptured due to severe heating in the vapor space.

Perry, Mich., June 2, 1961

Personnel went to a coffee break while an LP-Gas tank truck was being filled at the loading dock. What happened to cause the fire has not been reported, but vapors escaping from some source were ignited. When first seen, the fire was burning near an open electrical fuse panel on the loading dock. The tank truck, loading dock, and cylinder charging room were involved.

Fire fighters and plant personnel, expecting an explosion, removed everyone from the area. They waited 3 hours and 50 minutes. When a deputy state fire marshal arrived, he evaluated the area and directed fire fighters to cool equipment with hose streams, close LP-Gas valves, and extinguish the fire.

During the fire, exposed portable cylinders that were stored on the adjacent loading dock and on a flat-bed trailer truck exploded, some rocketing up to a block away.

Transportation Equipment

Automobiles

Magee, Miss., April 12, 1958

The operator of a gasoline service station stored cylinders of LP-Gas to be sold to customers on a cash and carry basis. On the date of the accident, the service station attendants were busy waiting on customers. A 16-year-old boy helped himself to a 100-pound cylinder from the storage room, put it in his car, then went inside the service station to pay for it. After paying for it, he drove several miles to a destination and shut off the motor. After taking the cylinder out of the car and restarting the car, a gas explosion occurred which burned his hands and face.

This cylinder had been placed in the back of the station wagon with planks on each side to prevent it from rolling.' It was later discovered that the valve on the cylinder was slightly open, allowing sufficient gas to escape to cause an explosive atmosphere in the car.

near Belgrade, Nebr., Oct. 1959

A man and wife arrived home at night and left their 1958 model automobile in the yard. At about 4:00 A.M. the automobile, which had been equipped to burn LP-Gas, exploded with such violence that it shook the house. Flames from the ensuing fire could be seen in Belgrade, eight miles away, as the Belgrade Fire Department answered the automobile owner's call to protect the house and farm buildings. The fuel tank remained intact, but the automobile was completely destroyed. The LP-Gas apparently had leaked into the automobile and had been ignited from an unknown source.

Mobile, Ala., July 19, 1960

A woman was critically burned by an explosion as she sat in an automobile while it was being refueled with butane by her brother-in-law. Butane, apparently escaping from leaking connections during the refueling operation, permeated the interior of the automobile and ignited from an unknown source. The brother-in-law received burns on his face and arms while pulling the woman from the blazing automobile. He said he had converted the car's fuel system to butane because it was cheaper than gasoline.

Freight Trains

Portland, Oreg., Oct. 18, 1954

At 3:48 A.M. LP-Gas leaking from a railroad tank car exploded. The explosion and resultant fire demolished or damaged 21 box

Portland Fire Department

Portland, Ore., Oct. 18, 1954. LP-Gas leaking from a railroad tank car caused extensive damage on igniting explosively. Photo shows LP-Gas burning harmlessly at the tank car vent nine hours after the explosion.

cars. Two 80,000 barrel fuel tanks 60 feet from the tank car were distorted and windows over a wide radius were broken. Fires broke out in wooden box cars and in combustible freight.

The explosion occurred as freight cars were being "spotted" in the railroad yards. Preceding the explosion a blowing sound was heard and a vapor cloud was seen to spread out from the leaking tank car for a distance of about 200 feet. When the vapors reached a kerosene-fueled switch lamp, flames flashed back through the cloud and reached explosive violence after traveling a few feet. Conventional fire fighting methods were used to extinguish the fire in freight cars. Water sprays were used to cool tank cars. Fortunately, none of the LP-Gas tank cars was damaged by the explosion, and the only fire involving these cars was at the dome of the leaking car. Vapors continued to burn at this car until 4:30 P.M.

Upon examination of the leaking car, it became evident that the leak resulted from a broken safety relief valve stem.

Shattuck, Okla., March 4, 1958

While a 142-car freight train was moving through Shattuck, a drawbar broke and caused this early morning derailment of 31 cars, including 22 cars of various petroleum products. An intense fire involving flammable liquids and LP-Gas released from ruptured tank cars broke out in the wreckage, and 15 minutes after the wreck, the first of six explosions occurred in tank cars. Some of the tanks were hurled several hundred feet, one flying 1,100 feet. Glass was broken and walls cracked within 10 blocks of the accident. Miraculously, no one in the nearby dwellings was injured seriously by this predawn accident.

Woodfin Camp

Shattuck, Okla., March 4, 1958. This derailment of 32 cars was involved in fire fed by flammable liquids and LP-Gas released from tank cars.

Wide World

near Merriam, Kans., July 20, 1958. Following derailment, fire fed by LP-Gas and flammable liquids burned for three days.

near Merriam, Kans., July 20, 1958

A broken wheel on a freight car was the probable cause of derailment of part of the speeding freight train. Fire fed by flammable liquids and LP-Gas released from tank cars required the use of hose streams for three days. Fire fighting was hindered by roads blocked by sight-seers, long pumper relays, the threat of explosion of two cars of ammunition (later found not to be among derailed cars), and explosions of compartments of tank cars.

near Meldrim, Ga., June 28, 1959, 23 killed

Twenty-three persons lost their lives, and a number of others were severely burned in an explosion and fire following a freight train wreck. The disaster occurred as the 124-car train crossed a wooden trestle spanning the Ogeechee River. Sixteen cars in the train became derailed and eleven cars, including two LP-Gas tank cars, plunged part way down an embankment at one end

of the trestle. A picnic area was at the foot of the trestle where more than 100 persons, including many children, were picnicking and bathing. Unfortunately, as the two LP-Gas tank cars rolled over the embankment, a car coupler or drawbar from the rear tank car was jammed through the head of the leading tank car. This large gash permitted LP-Gas to disperse over a very wide area until it was ignited, probably by a picnic cooking fire.

A detailed report of this disaster is published in the July 1960 QUARTERLY.

near Asbury, Mo., Dec. 31, 1960

Five tank cars of LP-Gas were involved in a derailment, four of which were completely destroyed by the wreck and the ensuing fire. Fortunately, the safety valves on the four cars were able to function and release the pressure created by exposure to the heat of fire. None of the LP-Gas tank cars ruptured, and the gas was allowed to burn off in a controlled fire. A tank car of ethylene oxide did, however, explode, probably due to the decomposition reaction of the ethylene oxide on exposure to severe heat.

Freight Trucks

Kansas City, Kans., July 24, 1952

The twin fuel tanks of a truck had just been filled to 90 per cent of capacity with LP-Gas, and the driver had entered the office to get his ticket and pay the billing for the fuel. A few minutes later the filling station attendant noticed that the relief valve on the right-hand fuel tank of the truck was discharging gas. The escaping gas drifted into the office and apparently was ignited by the flame on a gas-operated refrigerator. The truck driver and a woman working in the office of the filling station were critically injured. The blast was so violent that a woman two miles from the scene thought an earthquake was occurring.

Investigation revealed that, contrary to NFPA Standard No. 58, the discharge of the fuel tank relief valve was horizontal rather than vertical, and the exhaust pipe of the truck was next to the fuel tank. Heat from the exhaust pipe apparently raised the pressure in the fuel tank to the point where the relief valve opened.

Los Angeles, Calif., Sept. 17, 1953

A driver attempted to back his 8-foot-wide tractor with flat-bed semitrailer into a 10-foot opening between two buildings. The 1944 model tractor was equipped with two 85-gallon LP-Gas fuel tanks, interconnected by ⅜-inch copper tubing. These tanks were provided with obsolete valves and fittings. Each tank had eight separate openings: two ½-inch soft plugs, one ¾-inch service valve without excess flow protection, one ¾-inch vapor withdrawal and spring-loaded relief valve, one 10 per cent gage valve, one rotary gage valve, one 1¼-inch filler valve, and one ¾-inch vapor return valve. Both fuel tanks were filled to the legal limit at the time of the accident.

In trying to get into the narrow opening, the right side of the tractor scraped against the corner of a building and sheared off the service valve and the vapor withdrawal valve from the right tank. These two ¾-inch openings directly through the shell of the tank allowed LP-Gas to escape at a high rate and permeate the congested industrial area, which offered many sources of ignition. The first explosion alerted the occupants of the area, and someone telephoned the fire department. The heat probably fused the soft plugs on the fuel tanks, allowing the contents of the left tank to escape and ignite. Several other explosions occurred shortly thereafter, probably caused by the pocketing of LP-Gas in rooms and low places in the surrounding buildings. Seven persons were injured and damage was set at $200,000.

Middleburg, N. Y., April 9, 1955

A small LP-Gas heater had been placed inside the trailer to keep the cargo of bananas from freezing and to hasten artificial ripening. The heater was nailed to a board in the rear of the trailer, and the 20-pound-capacity propane cylinder was apparently tied to the side about five feet away from the heater. The two were interconnected by a piece of ½-inch inside diameter rubber tubing. There was neither pilot light nor automatic shutoff valve on the heater, and no provision had been made for ventilating the heater.

Apparently, the continuous operation of the heater with no outside vents caused complete consumption of the available oxygen in the trailer, thus causing the flame to go out. Since there was no automatic shutoff on the heater, LP-Gas continued to flow from the heater and fill the interior of the trailer. When the driver of the truck walked to the rear of the trailer and opened

the door, the inrush of air caused a flammable mixture of propane and air to form. The mixture ignited explosively from an undetermined cause.

The explosion shattered the trailer and inflicted first and second degree burns on the driver.

Boron, Calif., July 3, 1958, 1 killed

A man was attempting to unload a 1,000-gallon LP-Gas tank from a flat-bed truck by himself. Apparently, he attempted this by rolling the tank off with skids and rollers. He lost control of the tank and a quick-fill connection without excess flow valve was broken, allowing the entire contents, approximately 300 gallons, to escape into the surrounding atmosphere.

The source of ignition is not known, but the vapors did ignite. The ensuing fire was intensified by rupturing cylinders of LP-Gas, drums and cans of gasoline, oil, and paint, and other combustibles. The owner was fatally burned in the initial flash.

Mt. Pleasant, Texas, Sept. 29, 1959

The LP-Gas saddle tank on a tractor that hauled an asphalt semitrailer ruptured, apparently without warning or previous fire. The saddle tank, which had just been filled, was mounted by chains on the frame of the tractor in close proximity of the exhaust muffler. The relief valve was bent and showed no indication of having functioned.

Mt. Pleasant, Texas, Sept. 29, 1959. Failure of a pressure relief valve to open was believed responsible for rupture of a saddle tank on this tractor. Heat from the adjacent muffler probably caused the LP-Gas pressure in the saddle tank to increase.

Evidently, the heat from the muffler caused an overpressure in the tank when the relief valve failed to open. When the tank failed, it was torn from its mountings, flattened, and thrown about 50 feet from the truck.

Mattoon, Ill., Nov. 19, 1959

When the trailer was backed into the unloading dock, employees noticed smoke coming from inside the trailer. When the trailer doors were opened, the cargo burst into flames. The fire is thought to have originated from a defective LP-Gas cargo heater which had been installed in the trailer to protect the 156 cartons of hair spray in the cargo from freezing. The fire was intensified by exploding cans of hair spray. Fire fighters were endangered by the exploding cans and by the discharge of 22-caliber ammunition in the truck.

Industrial Lift Trucks

Baltimore, Md., July 25, 1959

A lift truck operator noticed that his LP-Gas-fueled vehicle was running hot, and he pulled into a wash rack area to put water in the radiator. While he was filling the radiator, there was a flash followed by fire around the motor and seat of the lift truck. Another lift truck was used to push the burning truck out of the building where the fire was extinguished.

Apparently, the hose connecting the LP-Gas cylinder to the engine developed a small leak. Movement of the lift truck prevented the escaping gas from accumulating, but when the driver stopped the truck for a few minutes, a small amount of gas accumulated around the motor and was ignited.

New Castle, Pa., Jan. 26, 1960

The operator of a lift truck had just finished refueling his vehicle from an outdoor 1,000-gallon LP-Gas storage tank. To do this, it was necessary to back the lift truck within three feet of the storage tank. In this position the truck's cylinder fittings, safety relief valve, and liquid hydrostatic relief valve faced the storage tank during the refueling operation. The operator had disconnected the fittings and returned the fill hose to its position over the storage tank. He

Warren Moody

Mattoon, Ill., Nov. 19, 1959. A defective LP-Gas cargo heater was the probable cause of fire that destroyed this truck trailer.

started the engine and almost immediately felt heat at his back. Turning, he saw a torch-like flame coming from beneath the engine hood. The heat exposure opened the fuel cylinder relief valve and also melted the gage fitting. Additional gas flames then burned at the two openings and radiated heat, and flame impingement opened the relief valve on the storage tank. Propane burned at the storage tank relief valve until all of the 500 gallons of fuel in the tank had been consumed.

Apparently gas leakage at the carburetor of the lift truck had ignited from an electrical spark when the motor was started. Examination of the engine components showed that fittings and portions of the vacuum switch adjoining the carburetor and the regulator were melted as if subjected to a direct LP-Gas flame impingement.

East Paterson, N. J., March 15, 1961

An employee had just finished refueling a lift truck with LP-Gas. When he disconnected the hose, a small amount of gas from the connection and possibly some from the bleeder valve on the container ignited. It was suggested that the gas might have ignited because either the employee was smoking or the lift truck was refueled with the motor running. The employee denied both.

LP-Gas Transport Trucks

near Carthage, Texas, Oct. 7, 1956, 4 killed

An employee, who had been working three weeks for an LP-Gas dealer, stopped on a public highway to bleed off pressure in his 5,900-gallon tank trailer before entering a plant to pick up a load of LP-Gas. Pressure relief facilities were provided inside the plant grounds for this purpose, and it is not known why the driver decided to bleed the tanks on a public highway.

As a man with his wife and daughter approached in their automobile, the driver of the tank truck flagged them down about 30 feet from the tank truck. The man driving the automobile evidently shut off his engine when he stopped, and when he stepped on the starter to restart his engine, a cloud of LP-Gas vapor that had enveloped the automobile ignited, fatally burning the three occupants of the automobile and the tank truck driver. Another woman and child in a second automobile were injured.

Herrin, Ill., Oct. 18, 1956, 9 killed

While the truck was parked at a bottled gas dealer's property, a leak in the tank truck filling line permitted LP-Gas to spread through a residential area. It eventually ignited explosively in a dwelling 175 feet from the leak. The dwelling was destroyed by the explosion, and three other dwellings were ignited and destroyed when flames flashed back through the vapor cloud.

Nine persons standing around were killed in the explosion and fire. Had these persons been evacuated from the area as soon as the danger became apparent, it is probable that no lives would have been lost.

Investigators found that the valve at the outboard end of the filling line was closed,

but that the valve at the inboard end was open. It is standard practice to keep both valves closed except during cargo tank filling. Had both valves been closed, the leak would have involved the contents of the filling line instead of the entire 1,000 gallons in the tank.

Sylvania, Ga., June 23, 1957

Five buildings were damaged by an explosion of propane that escaped from a tank truck. The truck was parked at the rear of an LP-Gas distributor's premises in a 125-foot-square yard, bounded on three sides by 1- and 2-story buildings. Fire ensued in three of the buildings.

Investigators determined that a clamp had failed on a 20-inch length of flexible hose that connected a cargo tank to the pump. Liquefied propane escaped, vaporized, and flowed to a restaurant 65 feet away, where it is believed the vapors entered a low kitchen window and ignited explosively at a kitchen range.

The truck was practically destroyed by the fire, but the two cargo tanks — one for propane and one for butane — were intact, the butane tank 70 per cent full, and the propane tank 15 per cent full after the fire had been extinguished.

Southwick, Mass., Dec. 21, 1957

This accident occurred at a dwelling in a residential area that used LP-Gas for a stove, a water heater, and a floor furnace. A 100-gallon tank was installed outside the kitchen wall between a window and the kitchen door. The driver of the LP-Gas truck had parked in the driveway about 30 feet from the tank. With the motor and pump running, he connected the hose nozzle to the tank. Before the nozzle was opened, however, the housewife came to the window and informed him that she did not want any gas.

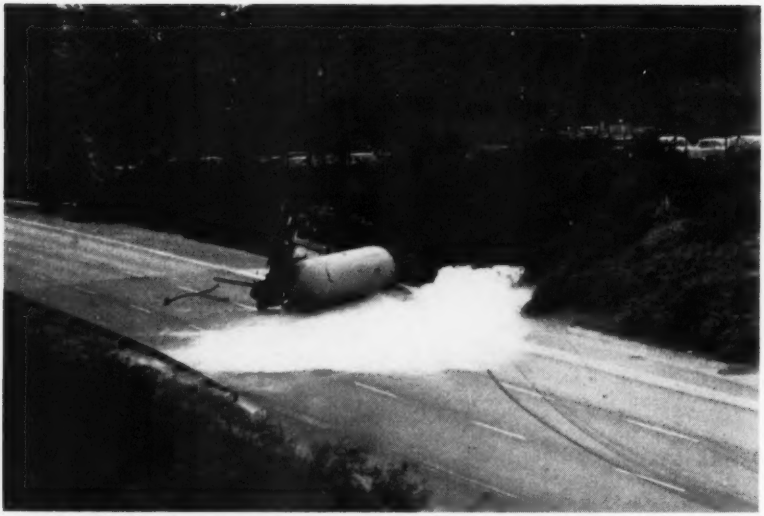
Because the tank was nearly empty and she was a regular customer, the driver went into the kitchen to find out why no gas was wanted. At that time the hose broke where it was connected to the nozzle. The driver heard the escaping gas and went out the door, leaving it open. He noted the liquid coming out of the hose and started for the truck to shut off the pump and motor. Before reaching it, the gas ignited and he was thrown 15 feet. He was not seriously injured and was able to shut off the motor.

The housewife ran out of the kitchen carrying one of her children and informed the driver that two others were inside. He entered and carried them out. All four occupants were burned. Damage to the house and contents was very severe. Investigation reveals that the excess flow valve in the hose had closed before the motor was shut off. Before that valve closed, however, sufficient gas had escaped to find its way through the open kitchen door and ignite at the pilot light on the stove. Further investigation revealed that a new nozzle had been recently installed on the truck hose, the installation of which might have been faulty.

Augusta, Ga., July 30, 1958, 1 killed

While transferring LP-Gas from a tank truck to an aboveground storage tank at an

Herrin, Ill., Oct. 18, 1956. Nine persons standing around watching the excitement occasioned by a leaking LP-Gas tank truck were killed when the leaking gas ignited explosively.



Los Angeles Fire Department

Los Angeles, Calif., Nov. 14, 1958. Following a collision with a passenger car, the tank truck load of LP-Gas overturned. A plug was knocked out of a gaging hole near the top front allowing LP-Gas to escape and flow into storm drains. Due in large part to the effective work of the fire department no fire ensued. Under cover of water spray a battalion chief plugged the hole, stopping the escape of gas.

industrial plant, the truck operator detected gas escaping from a defective fitting beneath the truck. After an unsuccessful attempt to stop the leak, he left the truck with the motor running and ran up and down nearby streets warning people to flee. Before his warning could be heeded, an explosion occurred that fatally burned one man, injured 16 others, destroyed five dwellings, and damaged 85 other buildings and automobiles. The only fire to follow the explosion involved the tank truck, two other trucks, and three automobiles.

Los Angeles Fire Department

Los Angeles, Calif., Nov. 14, 1958. Close-up of the plugged gaging hole, from which LP-Gas may be seen escaping in the other photo of this accident.

Los Angeles, Calif., Nov. 14, 1958

A fire did not occur at this accident, but its ominous threat caused anxious moments for fire fighters. A tank truck loaded with LP-Gas had collided with an automobile, causing the tank truck to overturn on the 12-lane superhighway. A plug was knocked out of a gaging hole in the top front of the trailer, leaving a ¾-inch unobstructed opening for the LP-Gas to escape. The LP-Gas was flowing and vaporizing directly in a gutter connected to a storm sewer opening 50 feet downhill and was also flowing to a drain across the wide thoroughfare. Responding fire fighters quickly diked up the drains, covered the leak with spray streams, and spotted fire companies all along a 3-mile front through the heart of Hollywood, terminating at the storm drain outlet at a country club.

After weighing the possibilities, it was decided to try to plug the hole in the tank rather than to let it empty and risk ignition. A battalion chief, covered by spray streams and wearing self-contained breathing equipment and rubber gloves, expertly drove a tapered wooden plug into the opening, using a rubber mallet. The tank truck was then set on its wheels by heavy-duty construction equipment and removed to a location where the LP-Gas could be transferred to another tank. Four hours after the accident the superhighway was given back to impatient motorists, and fire fighters returned to their quarters. One injury occurred when a man watching the action from atop an adjacent hill fell down the hill, breaking his leg, and interrupting the precarious work of the firemen. When the truck driver was asked if he tried to stop traffic on the opposite lanes of the artery after the accident had occurred, he replied "Yes, I tried, but frankly, I would rather take my chances on turning over the truck again."

Brownfield, Texas, Dec. 22, 1958, 4 killed

A pickup truck crossed the oncoming lane of a busy highway while making a turn and was hit by a twin barrel 5,000-gallon, butane gas semitrailer tank truck. The butane truck skidded, knocked down a heavy steel light post, and jackknifed. At this point the tractor separated from the trailer and headed across the lanes while the trailer continued down the road in its original direction, but on its back. As the trailer slid along, the safety relief valves and protective guards were probably ground down to almost nothing by the concrete paving.

The trailer came to rest on its back 225 feet from the impact point, and the tractor fuel system burst into flame. The driver, pinned in the cab, is thought to have died by then. In the meantime, one cargo tank, torn by the steel lamp post base, had flames coming from both ends. About 24 minutes after impact, an explosion took place that scattered parts of the tanks over 350 yards. As both tanks were inverted, the damaged safety relief valves in the second cargo tank undoubtedly could not adequately reduce the rapid pressure increase in this tank due to the severe exposure fire caused by the torn first tank. The fire marshal, a fireman, and a spectator were killed by this explosion. About 160 persons in the vicinity including spectators, fire fighters, and sundry officials were injured, 10 seriously.

near Deer Lake, Pa., June 2, 1959, 11 killed

Eleven spectators watching a burning LP-Gas tank truck lost their lives and ten others were injured when the cargo tank ruptured and rocketed up the road. The failure occurred 45 minutes after fire broke out at the rear of the filled 7,000-gallon cargo tank. At approximately 8:00 A.M., while the tank truck was stopped 60 feet behind a school bus, it was hit at the rear by a semi-tractor-trailer truck that was following and was unable to stop in time to avoid the collision. Seconds after the collision, LP-Gas leaking from impact-damaged piping on the rear of the tank ignited, and flames enveloped the rear portion of the tank truck.

A detailed report is published in the October 1959 Quarterly.

Pennsylvania State Police

near Deer Lake, Pa., June 2, 1959. Forty-five minutes after fire broke out at the rear of this LP-Gas tank truck the cargo tank ruptured and rocketed up the road, killing 11 spectators and injuring 10 others.

U. S. Army

Fort Devens, Mass., July 15, 1960. During transfer of LP-Gas from this transport to an aboveground tank, a 2-inch hose beneath the truck broke. Released gas ignited, and 15 minutes later the cargo tank ruptured near the top of the front head. The top of the front head was in direct line with the vent discharge from a saddle tank.

Fort Devens, Mass., July 15, 1960

A fire occurred at 9:10 A.M. when LP-Gas liquid escaped from a broken 2-inch hose connection underneath a tank truck during delivery to a 500-gallon storage tank. The released LP-Gas was probably ignited by gas-fueled kitchen equipment in a nearby mess hall.

Approximately 15 minutes after the initial hose failure, the large cargo tank on the truck ruptured near the top of the front head. This failure was apparently due to localized heating, as the top of the head was in direct line with the vent discharge from a safety relief device on an LP-Gas saddle tank. Three persons were burned when the tank ruptured. The fire destroyed the LP-Gas tank truck and a nearby army truck. Two 1-story wooden mess halls were badly damaged, and paint was blistered on four 2-story wooden barracks buildings in the area.

Prompt action by the Fort Devens Fire Department limited the extent of the fire and brought it under control within 40 minutes. Quick recognition of the danger by military personnel and the immediate warning and evacuation of those in the area prior to the rupture minimized personnel injuries.

A detailed report of this fire is published in the January 1961 QUARTERLY.

Nashua, N. H., Dec. 7, 1960, 1 killed by fire

Six persons were killed and about thirty injured when the driver of a truck delivering cylinders of LP-Gas failed to see an oncoming railroad diesel passenger car at a railroad crossing. The driver of the truck, his wife and two children in the truck were killed instantly by the crash as was a passenger who dived through the window of the train. The conductor of the one-car train was killed by fire when a ruptured LP-Gas cylinder was thrown into the front door of the train. Fire from this ruptured cylinder was also responsible for the many injuries.

Glen Loch, Pa., Dec. 15, 1960

The driver was returning to his plant with an empty tank trailer after having made a delivery of LP-Gas at a steel mill. He slowed his truck as he came to a low underpass where the highway went beneath a railroad. The driver had used this road many times before with both full and empty tanks, but a buildup of snow and ice on the roadway reduced the clearance under the railroad just enough for the safety valve on top of the tank trailer to be knocked off as the trailer passed under.

The driver heard the gas escaping from the opening in the tank, so he backed the truck free of the bridge, locked the brakes and ran from the truck. He ran to a nearby dwelling and asked the occupants to extinguish all their fires, and then called the fire department. At about the time he was telephoning the fire department, a train passed over the bridge, and sparks from the train apparently ignited the escaping gas.

The train was not damaged, but the concrete in the bridge was cracked in several places. Damage to the tractor and trailer was heavy.

Annandale, Va., Dec. 29, 1960

During transfer of liquefied petroleum gas from an 1,800-gallon tank truck to a dwelling storage tank, a flexible connection on the discharge side of the pump broke. The leakage was not great enough to actuate the excess flow valve, however, and before the driver could shut down the pump, the gas ignited. Fire fighters knocked down the fire with one 1-inch high pressure booster line and one 1½-inch hose stream, and then closed the shutoff valve.

near Sidney, Nebr., April 27, 1961

As a double-barreled LP-Gas truck rounded a curve on a newly graded roadway, the truck skidded and the driver lost control of the vehicle. The truck overturned, breaking off a valve on the butane tank piping, and the escaping gas burst into flame. The driver managed to escape, but received third degree burns to his hands and superficial burns of the face. Fire fighters cooled the tanks with hose streams for more than eight hours before the supply of gas from the tanks was exhausted.

Wide World

Nashua, N. H., Dec. 7, 1960. Collision of this train with a truck carrying LP-Gas cylinders caused one of the cylinders to rupture and to be hurled through the front door of the front car. Fire involving gas escaping from this cylinder killed the conductor and injured many passengers.

Al Chapman

Hart, Mich., Oct. 15, 1958. The owner of this travel trailer neglected to turn off the oven before changing gas containers.

Scranton, N. Dak., June 8, 1961, 1 killed

A full LP-Gas transport was connected for unloading into a 20,000-gallon horizontal LP-Gas storage tank. The truck driver was on top of the tank, preparing to open the discharge valve when a small explosion of undetermined cause and origin knocked him to the ground. A fire at the truck burned for about 10 minutes. It is not known whether there were any fire fighting efforts at this time or whether the fire department had been called. Suddenly, one head of the tank truck failed, and the tank shell rocketed 300 feet forward. A wave of burning gas moved rapidly in the direction opposite from tank travel about a quarter of a mile, igniting a grain elevator, an oil warehouse, and a pump house for an oil company. The driver was so burned that he subsequently died. Property damage was $400,000.

Travel Trailer

Hart, Mich., Oct. 15, 1958

The owner of the trailer had been using his oven when he ran out of LP-Gas. Later in the day, he installed a full tank of gas but had apparently forgotten to turn off the oven valve. Gas leaking from the oven was eventually ignited by a spark from a refrigerator motor in the trailer, and the explosion ripped out one side of the trailer and burned the occupant.

Watercraft

Terminal Island, Calif., Jan. 5, 1958

A gas leak is thought to have occurred during repairs to the LP-Gas cooking and water heating system aboard a 74-foot wooden-hull yacht. Repairs had just been completed after the vessel had suffered heavy damage in a storm at sea, and the odors of fresh paint in the galley probably masked the odor of the escaping LP-Gas. A woman, who was one of three persons aboard cleaning up the vessel, started to use the LP-Gas-fired stove in the galley to heat some water when the blast occurred. Since the weather was cool and she had on heavy clothing, she escaped with only first degree burns on her hands and face. The owner of the vessel and the other man aboard re-

ceived burns and fractures. There was no ensuing fire, but the blast itself almost destroyed the yacht, which was valued at approximately $100,000.

Manasquan, N. J., July 30, 1961

A propane-fired cookstove exploded from an unknown cause, and the ensuing fire caused extensive damage to the 60-foot yacht *Grey Goose*. Three of the eight persons on the yacht received burns, one of the three being thrown overboard by the blast.

Coast Guardsmen on a nearby patrol boat fought the fire unsuccessfully for some time and then beached the yacht so that the fire could be extinguished by the Manasquan Fire Department. By that time the fire had burned for well over an hour, and the *Grey Goose* was cooked.

Office Occupancies

Offices

Charleston, Miss., Sept. 23, 1954

Five men were injured when an accumulation of LP-Gas exploded in the 4-foot-high concealed space between the ground and first floor of the 1-story wooden office building. The building of origin was demolished, buildings on either side were severely damaged, and glass was broken over a 2-block area. The LP-Gas had leaked from a 15-year-old pipe in the subfloor space that carried butane into the building from a storage tank in the yard. The explosion occurred when a man in the building tossed a cigarette butt on the floor.

Delaware City, Del., Oct. 2, 1955

Fire that followed an explosion of LP-Gas in the not-cut-off furnace room, located in the center of the H-shaped building, spread over plywood and combustible fiberboard partitions and sheathing to both 8,000-square-foot wings of the 1-story masonry, steel-framed building. Investigators concluded that a diaphragm on a gas regulator had failed and that because of a hole in the regulator vent line, gas escaped into the furnace room instead of being conducted to outdoors.

Bank

Danville, Ark., Nov. 20, 1956, 1 killed

One bank employee was killed and another was severely injured by an explosion that occurred at 7:35 A.M., when one of them started to light an LP-Gas-fired radiant heater in a small office in the bank. These two men were the only persons in the building at the time. The explosion demolished the 1-story brick, wood-joisted bank building and an adjacent 1-story brick, wood-joisted pool hall.

The LP-Gas heater was supplied from an underground storage tank located behind the bank. Investigators uncovered the tank and found a ⅛-inch hole in the bottom. It is thought that LP-Gas leaking from the hole seeped through the ground and entered the bank.

Storage Occupancies

Beverage Warehouse

Warsaw, Ky., Dec. 25, 1959, 1 killed

The owner of a beer and soft drink distributing warehouse had experienced difficulty with the large, 1-million-Btu furnace with combination LP-Gas-oil burner. A service man had been called in the day before the explosion, and it is reported that the service man installed a new pilot in the furnace and checked all connections for leaks. The furnace seemed to operate properly until the end of the day, when the owner decided it would not be necessary to operate the furnace over the weekend because of the mild weather. He shut off the electric current to the furnace controls. A small LP-Gas heater in the office was left on.

The following morning a neighbor smelled gas but took no action. The owner returned to the warehouse at about the middle of the afternoon to pick up a package and noticed the odor of gas. In order to ventilate the building, he opened a large truck door at the front of the building and another at the back. As he was walking through the building toward the office, he heard the office heater come on automatically, followed immediately by a devastating explosion. The owner was rescued from beneath debris of the fallen building but died of burns nine days later.

The violence of the explosion is evidenced in the number of buildings damaged. Fifteen dwellings were so damaged that they had to be torn down, 16 other buildings received heavy damage, 75 had light to moderate damage, and 17 business houses received various degrees of damage. Fifteen persons received minor injuries.

The manner in which the LP-Gas escaped into the building is not definitely known. The combination gas and oil burner was not approved as a combination, although the oil burner proper and the individual controls were listed. The heating unit had been purchased second hand and originally had been equipped for use with natural gas. It is not known whether the unit had been converted for LP-Gas use. Loss was $1,250,000.

Department Store Warehouse

Los Angeles, Calif., Oct. 25, 1960

A workman using a propane torch was removing asphalt tile from an office floor when a rubber hose connected to a 10-gallon propane cylinder worked loose, causing a leak. The escaping propane ignited and set fire to melted asphalt tile. The heat from the fire opened the pressure relief valve on the cylinder, and the burning gas from this opening set fire to the combustible fiberboard ceiling. Ten sprinklers opened and extinguished the blaze before fire fighters arrived.

Grain Elevator

San Creek Junction, Colo., June 7, 1958

In order to provide a drain for water that collected in the 25-foot-deep grain dump for trucks, a hole was knocked in the concrete floor. The following morning, as a workman was cleaning up the broken concrete with a shovel, an explosion occurred that severely burned the workman and caused some structural damage to the grain dump.

Investigators found that underground pipes from three LP-Gas storage tanks to the grain elevator were so corroded that they would not maintain the normal 5 psi working pressure. It was concluded, therefore, that the explosion involved LP-Gas that had escaped from corroded underground piping and entered the grain dump through the hole in the floor.

Lumberyard

Sacramento, Calif., Dec. 9, 1959

Workmen were loading an LP-Gas tank onto a flat-bed truck with a fork-lift truck. The tank fell off the fork truck, breaking the relief valve and allowing LP-Gas to escape. The vapors were instantly ignited by the ignition system or hot exhaust on the lift truck or the flat-bed truck.

The initial fire found plenty to feed on to aid its spread, as the occupancy was a combination building materials sales and roofing

business with large quantities of lumber, paint, roofing, and related items.

Truck Terminal

San Jose, Calif., March 3, 1956

While butane was being transferred from a tank truck and trailer to aboveground storage tanks at this truck terminal, gas leaking from the hose was ignited, probably by the ignition system of the truck.

Recognizing the danger of extinguishing the fire until the leak was stopped, firemen used deluge sets supplied by eight 2½-inch lines to cool the storage tanks until valves could be closed. Most of the fire then went out, and that which continued to burn at the truck was extinguished by hose streams. The truck driver was seriously burned, and four trucks were destroyed.

Miscellaneous LP-Gas Fires and Explosions

Construction Operations

Westbrook, Me., Jan. 12, 1958, 1 killed

The contractor on an underground sewer construction project had employed a plumber to set up an LP-Gas heater to protect the newly poured concrete in a pumping station. Two 20-pound LP-Gas cylinders were connected through a regulator to the heater with rubber hose. The top of the structure and most of the openings were covered with tarpaulin.

During the weekend, the contractor found that the supply of gas had been exhausted, and he and one of his employees picked up the plumber and an extra cylinder of LP-Gas at the plumber's house. They went to the construction project and installed the new cylinder. While the heater was being relit, an accumulation of gas in the pit ignited and injured the plumber and the employee who were at the heater. The contractor, who was standing on a ladder, evidently received the full force of the explosion and died of burns.

It is not known whether gas escaped from a leak near the gas regulator or the burner went out because of lack of oxygen in the enclosed space of the pumping station. The heater did not have an automatic safety shutoff device.

West Lafayette, Ind., Dec. 9, 1960

Three LP-Gas-fired salamander heaters were being used to prevent newly poured concrete from freezing in the basement at a fraternity house under construction. A workman had turned off the gas to one of the heaters when he heard gas escaping from the hose on another. Realizing that the escaping gas might ignite at any moment, the workman fled up a ladder out of the basement just moments before the explosion. A leaking rubber hose supplying gas to a salamander was the source of the escaping LP-Gas.

New York, N. Y., Oct. 10, 1960

A cylinder of propane for fueling heaters that were used to dry out new concrete was being lowered into a 20-foot-deep by 300-foot-long excavation for a subway. Somehow, the cylinder broke loose and fell into the pit and apparently was punctured. The rapidly escaping gas ignited and critically burned the two workmen who were at the bottom of the excavation waiting to receive the cylinder.

New York, N. Y., Jan. 31, 1961

A concrete company was using LP-Gas-fired salamander heaters at a building construction job. During the night, one of the gas cylinders providing fuel for a salamander either fell over or was struck by a falling object, and the valve was broken off. The large volume of escaping LP-Gas was ignited by the flame in one of several salamanders on the job.

Two watchmen were injured, and windows in the neighborhood were shattered by the blast. The building under construction was damaged by the ensuing 3-alarm fire.

Rochester, N. Y., March 6, 1961

Two propane gas cylinders were being used to supply fuel for a salamander heater

at an underground garage and parking lot construction job. Apparently, the LP-Gas was escaping from a leaking connection and there was enough accumulation of vapors to cause an explosion when ignited by the salamander. Three workmen received minor burns in the flash.

Farm Property

near Alliance, Nebr., July 4, 1952

While turning his tractor around, the farmer backed it into a 300-gallon butane tank and knocked a valve off the tank. Butane sprayed on the farmer's clothes, so he ran to the wash house to remove them. The pilot light on a hot water heater in the wash house ignited the butane and severely burned the farmer, and his wife and daughter, who ran to his aid.

near Battle Creek, Nebr., Nov. 15, 1960

Rats had chewed through a hose which connected a propane cylinder to a water heater in a field. The heater was used to keep the drinking water for the farm animals from freezing. Escaping gas had ignited from the heater flame and destroyed the regulator on the gas cylinder and several fence posts.

near Preston, Md., April 4, 1961

A recently constructed 60-foot by 300-foot chicken house, occupied by 7,200 chicks, was heated by LP-Gas heaters. One of the heaters apparently developed a leak at the connections and set fire to wood shavings on the floor.

The LP-Gas supply tank near the chicken house was described as being about 20 feet long and 4 feet in diameter. Heat from the burning chicken house caused this tank to rupture before firemen arrived. Apparently, the pressure relief device on the tank failed to operate.

Fitchburg, Mass., June 23, 1961, 1 killed

The farmer and his wife were readying a large chicken house for the arrival of 6,000 chicks within the next few days. There were 10 LP-Gas-fired heaters in the building, and the farmer had detected a leak in one of them. When he took a cigarette lighter from his pocket and attempted to light one of the burners, an accumulation of LP-Gas vapors in the building ignited, killing the farmer and seriously burning his wife.

Internal Combustion Engine

Telogia, Fla., April 24, 1958

Even the fire pump itself is not immune to fire. Employees in the safety department were testing nozzles which were supplied by a fire pump driven by an LP-Gas engine. After the tests were completed, the safety supervisor went to the fire pump to shut it off, and as he was shutting it off, fire suddenly developed at the pump. The supervisor was burned painfully, but not severely, and other employees in the area extinguished the fire with dry chemical extinguishers. A broken fuel line allowed LP-Gas to escape which ignited from the engine ignition or exhaust.

Telephone Exchange

Stone Lake, Wis., April 26, 1961

LP-Gas leaking from a defective fitting in the heating system of a 1-story hollow tile, wood-joisted, unattended telephone exchange was ignited. A spark from telephone switch gear was the probable ignition source. The explosion blew all four walls outward, and the roof collapsed. There was no subsequent fire, and telephone service was restored in seven hours.

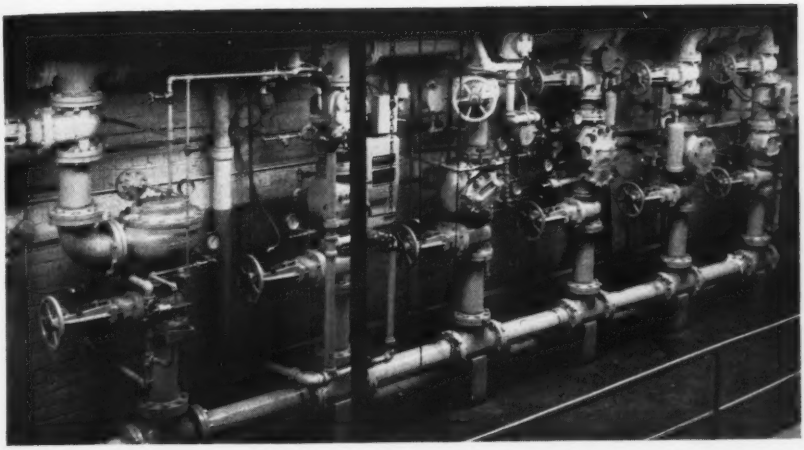
Well Drilling

Cantex, Sask., March 5, 1956

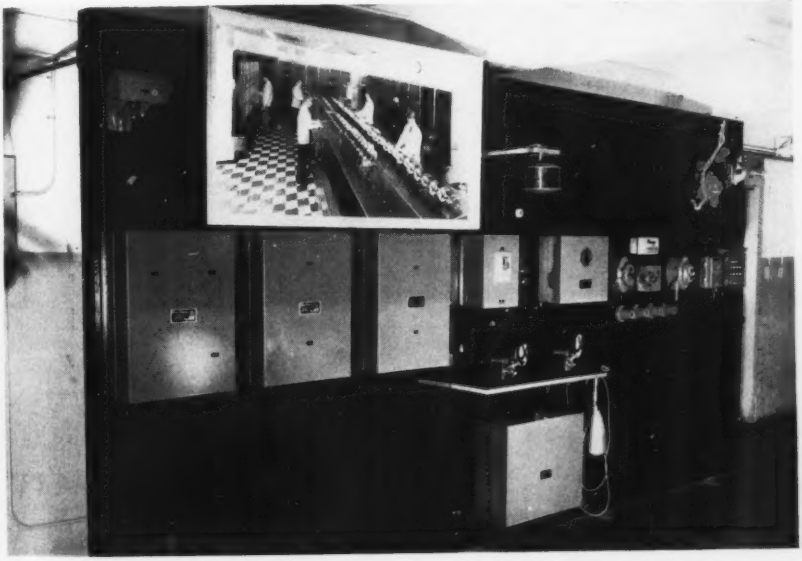
A well drilling rig was being set up when workmen noticed that the excess flow valve on an LP-Gas tank was leaking. The gas supply company was called to replace the valve and fill the tank with LP-Gas. Meanwhile, the workmen moved the tank 300 to 400 yards out onto the prairie away from the rig, in order to bleed off the small amount of gas that was left in the tank.

Some welders arrived at the well location, and seeing the workmen at the LP-Gas tank, drove in that direction. They had driven their truck into the escaping vapors before the workmen noticed their approach and warned them to get their truck out of the area. When the truck driver attempted to restart the motor of his truck, a spark from the ignition system on the vehicle ignited the LP-Gas vapors. The truck driver was badly burned, and the truck was completely destroyed. The LP-Gas tank was undamaged.

IIT's New Hydraulic Laboratory



Six sprinkler valve test stands are among the equipment of a fire protection engineering laboratory opened in May 1961 at Illinois Institute of Technology, Chicago. Assemblies, left to right: two deluge valves, two dry-pipe valves, and two alarm check valves.



Eighteen-foot panel for central station supervisory, water-flow, and fire-detection equipment at new fire protection engineering laboratory of Illinois Institute of Technology.

Fires and Fire Losses Classified, 1960

Editor's Note: During recent years NFPA members have called attention to instances where certain parts of this article, notably Table VI, have been taken out of context and misused in advertisements and otherwise. Readers are reminded that material published in the QUARTERLY is copyrighted and may not be reproduced in whole or in part without written permission from the Association. This article is available from the Association in pamphlet form.

There were 2,123,860 fires of all types in the United States in 1960 causing a loss of $1,544,200,000, according to estimates compiled by the National Fire Protection Association. The 1960 loss was an increase from that of 1959, when the estimated loss was $1,439,640,000. This is the worst loss record in U. S. history. The 2,123,860 fires in 1960 were 9,500 more than in 1959.

Building fires in the U. S. in 1960 totaled 890,200 and caused $1,139,700,000 damage. An additional 1,233,660 fires not involving buildings — aircraft, motor vehicles, forests, ships, rubbish, grass fires, etc. — accounted for an estimated $404,500,000. Building fire estimates for 1959, reported in the October 1960 QUARTERLY, showed 883,300 fires with $1,083,210,000 loss.

A notable change in the 1960 occupancy experience (Table VI) from that of 1959 was in the broad classification Residential Occupancies. Fire in Residential Occupancies increased 18,000 in number from 1959 and caused $24,910,000 more loss. This change was primarily due to increases in dwelling experience of 21,000 fires and $34,200,000 loss. Storage losses decreased 16,000 in number and $13,460,000 in total damage, as compared with 1959.

Ship and Other Transportation fires, while experiencing 200 fewer fires, showed a loss increase over 1959 of $48,680,000. The aircraft carrier "Constellation" fire in December 1960 accounted for most of this change. A favorable change in the 1960 fire experience was in farm buildings (excluding dwellings), where records indicate a decrease of 18,300 fires.

Building fire losses by cause are estimated in Table V. Principal changes in the 1960 reported cause experience involved fires attributed to Heating and Cooking Equipment and to Electrical causes. Fires from all types of heating and cooking equipment increased a total of 7,300, tallying a $25,840,000 additional loss. Electrical fires increased 7,000 but losses dropped $6,200,000.

Methods of Compiling Data

The data from which Tables I to IV were compiled were obtained from 18 state fire marshals' reports for the year 1960 or the closest fiscal year thereto.

While the methods of reporting and tabulating fire loss figures differ from state to state, the volume of statistics from the 18 typical states chosen, representing all sections of the country and including both primarily agricultural and industrial states, is sufficiently large to indicate the relative distribution of fires and fire losses. Table I shows the number of fires by occupancy in 17 states and Table II the loss by occupancy in 13 states. Tables III and IV list the

(Continued on page 222)

TABLE I. Number of Fires by Occupancies in Seventeen States — 1960

	Conn.	Del.	Ill.[1,8]	Iowa	Kans.	Ky.	La.	Minn.[7]	Mont.	Nebr.	N. H.	N. D.[2,4,8]	Ohio	Oreg.[4]	S. D.[1]	Vt.[1,4]	Wyo.	Totals
PUBLIC ASSEMBLY OCCUPANCIES																		
Amusement, recreation halls	5	...	31	2	...	14	...	...	1	...	3	...	...	...	1	...	...	57
Bowling alleys	...	...	11	3	...	...	...	...	2	...	...	...	...	...	...	1	...	17
Churches	8	4	34	10	10	40	37	12	2	10	6	6	52	31	8	6	8	284
Clubs, club houses	7	...	...	16	...	...	...	15	3	...	10	...	...	...	1	6	5	63
Restaurants, taverns	72	18	253h	70	12	55	...	84	26	27	17	...	256	134	7h	6	27	1,064
Theaters, incl. motion picture	3	...	3	3	2	5	17	4	...	4	...	...	...	9	...	1	1	52
Other public assembly occupancies	6	...	11	9	11	...	...	15	3	1	2	...	...	42	3	1	18	122
EDUCATIONAL OCCUPANCIES	18	7	33	16	10	38	126	18	2	15	7	3	57	57	22	6	5	440
INSTITUTIONAL OCCUPANCIES																		
Hospitals	4	4	17	7	5d	9d	...	8	...	...	7	...	30	...	1d	1	2	95
Other institutional occupancies	1	...	5	7	1	...	36t	2	3	3	4	1	12	...	1	1	3	80
RESIDENTIAL OCCUPANCIES																		
Apartments	218	174	291b	149	63	57b	...	216c	...	117b	65	...	937	...	11	5	18	2,321
Dwellings, one and two family	1,134	1,063	4,128	1,184	1,205	3,987	5,226b	1,518	511i	601	752	390i	6,026	12,944i	478	382	541	42,070
Hotels	15	11	98c	33	38g	36c	242g	49	...	23	26	18j	159n	308m	45s	15	14c	1,130
Motels	...	...	...	10	...	...	...	3	6	8	3	...	...	...	...	3	13	46
Rooming, boarding houses	37	22	...	2	5	...	...	...	...	...	5	...	...	...	...	...	...	71
Summer cottages, camps	12	...	...	...	14n	...	...	5	1	...	59	...	...	...	...	2	...	93
Trailers, trailer courts	...	44	156	46	...	...	...	27	11	40	18	...	204	...	27	9	61	643
Other residential occupancies	...	10	...	5	...	...	...	...	...	...	...	...	...	...	...	...	1	16
MERCANTILE OCCUPANCIES																		
Food stores, incl. supermarkets	...	...	...	29	4	...	...	...	6	...	...	...	...	...	...	2	12	53
Service stations	10	2	58	32	40f	...	...	31	...	...	5	...	91	...	67f	2	22	360
Other mercantile occupancies	182i	268i	384	112	177	149k	563k	282	46	28	70	45	434	384k	66r	41	47	3,278
OFFICE OCCUPANCIES																		
Government buildings	...	...	...	1	...	16	...	2	1	...	4	46	...	...	2	2	63	137
Offices, banks, other office occupancies	...	38	77	19	14	...	...	43	7	17	...	63	98	...	3	1	21	401
INDUSTRIAL OCCUPANCIES																		
Chemical, chemical products	...	...	...	...	16	...	16	...	3	...	...	10	...	11	...	...	...	56
Food, food products	5	...	10	13	13	115	25	8	8	35	6	35	...	62	5	2	3	345
Metal, metal products	7	...	76	7	15	6	22	...	5	...	4	2	...	20	...	5	11	180
Wood, wood products	1	...	3	...	2	3	20	...	1	...	17	...	...	144	1	5	2	199
Other industrial buildings and occupancies not reported	79	56	261	90	55	130	143	118	21	89	60	45	522	130	14	18	38	1,869
STORAGE OCCUPANCIES																		
Barns	125a	13	251a	157	...	244	281a	214	16	235a	37	269a	...	301a	93	...	...	2,236
Farm property, other	...	43	342	92	322	44	...	70	49	...	54	...	...	...	13	309e	87	1,425
Garages, residential parking	122f	...	612	185	147	...	...	373	42	113	23	...	772	...	...	8	13	2,410
Grain elevators	...	...	14	10	12	...	...	2	3	...	...	...	...	...	9	...	7	57
Grain, feed, seed, hay storage	...	...	20	25	...	...	...	28	...	...	...	...	...	...	31	...	...	104
Lumberyards	7	...	10	6	3	17	20	6	12	6	1	4	...	...	...	...	9	101
Other storage occupancies	30	9	81	139	26	55	80	169	15	12	4	7	148	44	24	8	10	861
OTHER BUILDINGS, OCCUPANCIES NOT REPORTED	278	1,187	308	7	1	276	58	113	27	14	...	12	3,857	9	19	3	...	6,169
OTHER THAN BUILDING FIRES																		
Outdoor fires, except transportation	...	1,276	105	48	1	2	...	4	295	164	2	...	280	...	246	...	674	3,097
Transportation fires	325	593	2,460	641	576	138	1,129p	323	36	585	...	...	3,940	873	246	...	385	12,250
Totals	2,711	4,842	10,143	3,185	2,800	5,436	8,041	3,762	1,164	2,147	1,271	956	17,875	15,503	1,444	851	2,121	84,252

[1] Fiscal year ended June 30, 1961.
[2] Fiscal year ended June 30, 1960.
[4] Number of insurance claims.
[6] No losses less than $100.
[7] No losses less than $25.
[8] Outside Chicago.

a. Includes other farm property.
b. Includes flats and rooming houses.
c. Includes boarding houses.
d. Includes other institutions.
e. Includes all rural property.
f. Includes repair garages.
g. Includes motels, boarding houses, clubs.
h. Includes night clubs.
i. Includes flats and apartments.
j. Includes clubs and theaters.
k. Includes office buildings.
m. Includes motels and rooming houses.
n. Includes motels.
p. Includes public utilities.
r. Includes warehouses.
s. Includes motels and restaurants.
t. Includes public buildings.

TABLE II. Fire Losses by Occupancies in Thirteen States — 1960

Losses were reported by the states to the nearest dollar. They are reported in thousands in this table.

	Conn.	Ill.[1,8]	Iowa	Kans.	Ky.	La.	Minn.[7]	Nebr.	N. D.[2,3,6]	Ohio	Oreg.[3]	S. D.[1]	Vt.[1,3]	Totals
PUBLIC ASSEMBLY OCCUPANCIES														
Amusement, recreation halls	$ 8.3	$ 232.5	$ 3.6	$	$ 685.1	$	$	$	$	$	$	$ 7.2	$	$ 936.7
Bowling alleys	.....	519.7	78.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	0.1	598.1
Churches	7.6	334.6	113.1	18.6	156.8	163.8	290.6	117.7	9.0	310.7	106.5	105.1	12.6	1,746.7
Clubs, club houses	146.9	.....	392.1	.....	.....	.....	34.3	.....	.....	.....	.....	6.0	16.1	595.4
Restaurants, taverns	464.8	1,343.2h	235.7	133.2	273.1	.....	469.6	210.3	.....	1,250.8	353.1	10.3h	37.3	4,781.4
Theaters, including motion picture	1.0	2.1	3.3	0.1	1.5	214.9	18.2	25.8	.....	.....	75.0	.....	0.3	342.2
Other public assembly occupancies	20.8	135.8	18.2	431.5	.....	.....	291.1	0.5	.....	.....	91.1	3.7	0.7	993.4
EDUCATIONAL OCCUPANCIES	9.1	85.1	444.9	51.7	605.1	971.4	13.9	29.1	2.3	302.8	574.8	1,656.2	164.3	4,910.7
INSTITUTIONAL OCCUPANCIES														
Hospitals	0.6	4.1	9.9	.8d	8.2d	.....	0.7	.....	.....	17.7	.....	0.3d	0.1	42.4
Other institutional occupancies	.....	0.5	4.9	2.0	.....	110.1t	0.1	24.5	0.2	4.4	.....	0.2	0.1	147.0
RESIDENTIAL OCCUPANCIES														
Apartments	382.7	410.4b	225.1	26.5	405.0b	.....	361.6c	223.2b	.....	1,228.1	.....	2.9	2.1	3,267.6
Dwellings, one- and two-family	2,629.2	7,146.5	2,929.2	1,178.0	9,762.4	7,356.4b	3,852.5	1,340.0	403.1i	10,911.7	6,775.8i	612.5	618.7	55,516.0
Hotels	36.8	240.2e	54.2	120.2g	122.7e	344.9g	98.8	106.5	14.2j	171.2n	333.1m	116.9s	151.8	1,911.2
Motels	.....	.....	30.3	.....	.....	.....	0.9	22.2	.....	.....	.....	.....	1.6	55.0
Rooming, boarding houses	63.4	.....	0.9	1.3	.....	.....	.....	.....	.....	.....	.....	.....	.....	65.6
Summer cottages, camps	37.2	.....	.....	16.7n	.....	.....	2.6	.....	.....	.....	.....	.....	0.9	57.4
Trailers, trailer courts	.....	302.3	106.1	.....	.....	.....	46.0	90.2	.....	284.4	.....	43.5	13.0	885.5
Other residential occupancies	.....	.....	37.1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	37.1
MERCANTILE OCCUPANCIES														
Food stores, incl. supermarkets	.....	.....	155.2	82.0	.....	.....	.....	.....	.....	.....	.....	.....	30.1	267.3
Service stations	5.3	122.2	75.9	98.5f	.....	.....	137.3	.....	.....	68.2	.....	241.9f	0.3	749.6
Other mercantile occupancies	1,333.6i	3,683.7	1,450.0	751.1	1,365.1k	2,230.5k	4,241.8	568.9	239.2	2,766.4	1,544.1k	318.0r	160.9	20,653.3
OFFICE OCCUPANCIES														
Government buildings	.....	.....	0.5	.....	32.1	.....	20.0	.....	265.3	.....	.....	1.3	6.4	325.6
Office buildings, banks, other office occupancies	.....	242.4	32.5	91.9	.....	.....	245.0	183.9	459.7	188.5	.....	10.6	1.1	1,455.6
INDUSTRIAL OCCUPANCIES														
Chemical, chemical products	.....	.....	.....	179.9	.....	405.0	.....	.....	14.5	.....	412.2	.....	.....	1,011.6
Food, food products	1.1	242.6	23.8	13.7	1,261.6	295.6	66.6	735.4	654.5	.....	1,198.1	6.1	2.9	4,502.0
Metal, metal products	19.3	462.2	6.6	490.0	29.7	178.6	.....	.....	9.2	.....	26.8	.....	4.5	1,226.9
Wood, wood products	1.0	20.0	.....	10.5	29.5	1,666.2	.....	.....	.....	.....	2,589.0	3.1	6.4	4,325.7
Other industrial buildings and occupancies not reported	694.9	1,452.6	1,086.0	191.3	908.2	1,168.2	3,344.5	428.5	310.2	3,161.0	1,131.3	52.6	216.5	14,125.8
STORAGE OCCUPANCIES														
Barns	590.2a	1,978.5a	1,048.6	.....	696.5	915.6a	1,455.4	690.3a	448.0a	.....	971.9a	250.4	.....	9,045.4
Farm property, other	.....	244.1	325.7	948.3	38.1	.....	673.4	.....	.....	.....	.....	14.2	1,058.9e	3,302.7
Garages, residential parking	235.5f	1,088.3	250.0	61.9	.....	.....	364.6	75.2	.....	857.9	.....	.....	7.6	2,941.0
Grain elevators	.....	624.3	141.7	241.8	.....	.....	8.0	.....	.....	.....	.....	225.3	.....	1,241.1
Grain, feed, seed, hay storage	.....	152.4	945.2	.....	.....	.....	36.2	.....	.....	.....	.....	65.6	.....	1,199.4
Lumberyards	6.5	360.2	194.6	16.7	664.8	65.9	34.9	67.8	7.3	.....	.....	.....	.....	1,418.7
Other storage occupancies	135.8	1,252.7	670.2	343.7	777.2	1,087.5	363.5	26.5	29.3	1,486.7	297.8	56.3	5.2	6,532.4
OTHER BUILDINGS, OCCUPANCIES NOT REPORTED	2,838.2	438.7	3.3	0.4	1,330.5	325.4	318.2	88.5	42.1	14,031.2	3.7	9.9	5.5	19,435.6
OTHER THAN BUILDING FIRES														
Outdoor fires, not involving transportation	.....	42.9	46.2	2.0	2.5	.....	3.5	140.5	.....	22.8	.....	74.0	.....	334.4
Transportation fires	184.7	1,456.5	345.5	232.5	167.5	558.6p	329.0	486.1	.....	2,797.8	134.6	120.7	.....	6,813.5
TOTALS	$9,854.5	$24,621.3	$11,488.4	$5,736.8	$19,323.2	$18,058.6	$17,122.8	$5,681.6	$2,908.1	$39,862.3	$16,618.9	$4,014.5	$2,526.0	$177,817.0

[1] Fiscal year ended June 30, 1961.
[2] Fiscal year ended June 30, 1960.
[3] Insured losses only.
[6] No losses less than $100.
[7] No losses less than $25.
[8] Outside Chicago.

a. Includes other farm property.
b. Includes flats and rooming houses.
c. Includes boarding houses.
d. Includes other institutions.
e. Includes all rural property.
f. Includes repair garages.
g. Includes motels, boarding houses, clubs.
h. Includes night clubs.
i. Includes flats and apartments.
j. Includes clubs and theaters.
k. Includes office buildings.
m. Includes motels and rooming houses.
n. Includes motels.
p. Includes public utilities.
r. Includes warehouses.
s. Includes motors and restaurant
t. Includes public buildings.

[3] Insured losses only.
[6] No losses less than $100.
[7] No losses less than $25.
[8] Outside Chicago.

b. Includes flats and rooming houses.
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j. Includes clubs and theaters.
k. Includes office buildings.

n. Includes motels.
p. Includes public utilities.
r. Includes warehouses.
s. Includes motors and restaurant
t. Includes public buildings.

TABLE III. Number of Fires by Causes in Seventeen States — 1960

	Conn.	Ill.[1,8]	Iowa	Kans.	Ky.	La.	Mich.	Mont.	Nebr.	N. H.	N.D.[2,4,6]	Ohio	Oreg.[4]	R. I.[5]	S. D.[1]	Vt.[1,4]	Wyo.	Totals
Heating and cooking																		
Equipment defective or overheated	165	1,006	240	173	421	377	6,422	106	103	223	99	...	881	126	163	122	113	10,740
Chimneys, flues defective or overheated	71	305	115	45	492	51	1,552	48	49	147	17	...	846	32	...	115	39	3,924
Hot ashes and coals	4	687	21	44	136	...	260	3	15	5	...	...	1,128	...	...	4	94	2,401
Combustibles near heaters	7	...	192	...	13	...	...	35	33	19	...	...	...	...	...	...	50	349
Smoking and matches	471	1,563	607	311	433	840	5,125	131	272	170	76	2,939	3,663	108	200	67	185	17,161
Electrical																		
Fixed services, fires due to wiring, equipment, etc.	142	928	426	381	725	1,012a	2,447	76	269	114	172a	2,642a	1,069	151a	246a	79	163	11,042
Power consuming appliances	155	426	116	27	96	...	3,569	16	172	95	...	...	1,310	...	...	11	95	6,088
Static, static sparks	...	...	...	...	...	4	...	1	...	4	1	33	...	...	...	...	...	43
Rubbish, source of ignition unknown	...	188	1	89	123	...	6,781	...	122	17	...	...	35	23	108	...	...	7,487
Flammable liquid fires and explosions not reported in Heating and cooking	148	554	242	249	420	...	586	70	191	104	...	...	2,546	78	87	44	84	5,403
Open flames and sparks																		
Sparks on roof	...	90	...	8	3	...	194	...	...	...	...	...	139	...	...	...	...	434
Welding and cutting	...	...	40	...	...	41	...	7	39	15	12	122	...	...	11	...	73	360
Sparks from machinery, friction	1	114	110	7	13	27	...	...	91	16	6	...	38	...	19	1	35	478
Thawing pipes	2	...	9	...	...	...	258	...	18	1	...	...	...	...	9	2	...	299
Miscellaneous open flames and sparks	109	...	144	83	38	929	638	38	4	25	80	3,923	807	40	128	31	...	7,017
Lightning	35	169	77	100	785	716	618	26	88	88	60	219	93	18	65	25	37	3,219
Children and matches	160	...	...	...	...	...	2,864	67	116	74	...	...	268	...	...	15	139	3,703
Exposure	39	199	174	111	72	560	...	68	105	22	56	255	786	4	15	31	501	2998
Incendiary, suspicious	98	131	50	28	40	202	1,393	2	26	30	5	...	112	178	...	7	20	2,322
Spontaneous ignition	27	115	60	6	37	36	3,137	16	33	23	10	390	106	10	35	7	32	4,080
Gas fires and explosions not reported in Heating and cooking	...	49	29	40	56	...	...	9	29	11	...	...	184	8	26	5	31	477
Explosions, miscellaneous and unclassified	9	38	7	80	56	...	...	22	10	...	...	...	26	...	11	15	3	277
Fireworks, firecrackers, and rockets	...	3	...	8	3	9	...	7	10	...	4	...	35	...	11	...	25	115
Miscellaneous known causes	684	1,932	72	155	...	334	18,738	3	25	19	123	5,509	35	211	96	56	223	28,215
Unknown or undetermined	384	1,646	453	975	1,474	2,903	6,251	413	327	49	235	1,843	1,396	222	214	214	150	19,149
Totals	2,711	10,143	3,185	2,920	5,436	8,041	60,833	1,164	2,147	1,271	956	17,875	15,503	1,209	1,444	851	2,092	137,781

[1] Fiscal year ended June 30, 1961.
[2] Fiscal year ended June 30, 1960.
[4] Number of insurance claims.
[5] Fiscal year ended Sept. 30, 1960.
[6] No losses less than $100.
[8] Outside Chicago.

a. Includes electrical power consuming appliances.

TABLE IV. Fire Losses by Causes in Twelve States — 1960

Losses were reported by the states to the nearest dollar. They are reported in thousands in this table.

	Conn.	Ill.[1,5]	Iowa	Kans.	Ky.	La.	Nebr.	N. D.[2,3,6]	Ohio	Oreg.[3]	S. D.[1]	Vt.[1,3]	Totals
Heating and cooking													
Equipment defective or overheated	$406.4	$ 2,050.7a	$ 717.4	$ 608.2a	$ 1,319.2a	$ 686.8a	$ 270.8a	$ 202.3	.....	$ 659.2a	$ 234.2	$ 174.3	$ 7,329.5
Chimneys, flues defective or overheated	118.1	395.3	269.1	57.8	1,379.1	58.8	171.2	17.5	.....	643.9	.....	91.6	3,202.4
Hot ashes and coals	0.9	1,028.5	48.1	17.6	355.0	.....	8.9	.....	.....	695.5	.....	1.0	2,155.5
Combustibles near heaters	5.0	.....	316.9	.....	258.6	.....	122.4	.....	.....	.....	.....	.....	702.9
Smoking and matches	955.7	1,219.3	950.3	133.0	694.9	346.6	235.0	79.1	3,612.2	757.1	232.7	45.5	9,261.4
Electrical													
Fixed services, fires due to wiring, equipment, etc.	521.6	2,558.4	1,786.1	462.2	4,314.8	1,651.3a	478.4	591.0a	6,415.2a	2,247.4	638.0a	221.2	21,885.6
Power consuming appliances	282.1	294.8	463.3	8.5	106.8	.....	233.6	.....	.....	439.5	.....	6.3	1,834.9
Static, static sparks	.....	.....	.....	.....	.....	4.7	.....	1.9	69.4	.....	.....	.....	76.0
Rubbish, source of ignition unknown	.....	223.5	0.2	37.1	146.5	.....	131.8	.....	.....	11.2	79.0	.....	629.3
Flammable liquid fires and explosions not reported in Heating and cooking	172.7	936.3	873.5	228.6	1,209.8	.....	148.2	.....	.....	464.6	95.5	19.6	4,148.8
Open flames and sparks													
Sparks on roof	.....	115.2	.....	29.8	5.4	.....	.....	.....	.....	151.4	.....	.....	301.8
Welding and cutting	.....	.....	114.4	.....	.....	522.0	151.4	61.7	222.3	.....	46.9	.....	1,118.7
Sparks from machinery, friction	6.0	82.7	178.2	16.8	30.0	26.3	155.7	275.7	.....	46.1	16.0	0.2	833.7
Thawing pipes	1.0	.....	7.3	.....	.....	.....	26.8	.....	.....	.....	720.1	2.1	757.3
Miscellaneous open flames and sparks	249.4	.....	164.9	231.6	64.6	1,234.1	4.0	196.6	5,602.6	338.0	349.0	91.2	8,526.0
Lightning	138.6	422.8	482.2	367.4	1,944.3	668.1	220.4	51.0	831.6	71.6	72.5	39.5	5,310.0
Children and matches	210.7	.....	.....	.....	.....	.....	167.2	.....	.....	248.2	.....	34.7	660.8
Exposure	214.1	646.6	348.4	86.5	817.2	573.4	80.5	162.5	549.6	964.5	12.2	24.0	4,479.5
Incendiary, suspicious	411.6	311.9	85.8	28.2	203.9	1,501.3	56.6	4.4	.....	952.0	.....	147.6	3,703.3
Spontaneous ignition	110.8	655.3	464.1	5.5	97.9	188.4	55.0	40.8	1,170.5	1,054.2	138.1	18.4	3,999.0
Gas fires and explosions not reported in Heating and cooking	.....	105.7	100.8	34.2	192.8	.....	79.4	.....	.....	117.2	64.6	10.0	704.7
Explosions, miscellaneous and unclassified	93.5	178.5	25.5	74.5	461.4	.....	53.2	.....	.....	27.1	21.5	71.8	1,007.0
Fireworks, firecrackers, and rockets	.....	0.1	.....	21.4	1.2	2.4	3.5	1.1	.....	11.9	21.1	.....	62.7
Miscellaneous known causes	2,274.5	1,829.0	74.7	161.7	.....	211.0	134.2	395.1	9,338.0	423.8	60.8	60.1	14,962.9
Unknown or undetermined	3,681.8	11,566.7	4,017.2	3,126.2	5,716.8	10,383.4	2,693.4	827.4	12,050.9	6,294.5	1,212.3	1,466.9	63,040.5
Totals	$9,854.5	$24,621.3	$11,488.4	$5,736.8	$19,323.2	$18,058.6	$5,681.6	$2,908.1	$39,862.3	$16,618.9	$4,014.5	$2,526.0	$160,694.2

[1] Fiscal year ended June 30, 1961.
[2] Fiscal year ended June 30, 1960.
[3] Insured losses only.
[5] No losses less than $100.
[6] Outside Chicago.

a. Includes electrical power consuming appliances.

Table V. Estimated U. S. Building Fire Losses by Causes, 1960

These estimated figures are intended to show the relative order of magnitude of fire losses by causes, and to indicate year-to-year trends. While they are reasonable approximations based on the experience in typical states, they should not be taken as exact records for each class. These figures by themselves do not show the relative safety in utilization of various types of material, devices, fuels, or services and should not be used for this purpose. Reproduction of this table in whole or part is not authorized without written permission from the Association, and identification of figures as "National Fire Protection Association estimates."

	No. of Fires		Losses	
Heating and cooking		209,300		$ 163,600,000
Equipment, defective or overheated	137,700		$112,400,000	
Chimneys, flues defective or overheated	40,400		27,600,000	
Hot ashes and coals	20,100		15,000,000	
Combustibles near heaters	11,100		8,600,000	
Smoking and matches		141,200		69,500,000
Electrical		129,900		187,000,000
Fixed services, fires due to wiring, equipment, etc.	76,500		139,000,000	
Power consuming appliances	53,400		48,000,000	
Rubbish, source of ignition unknown		53,900		10,800,000
Flammable liquid fires and explosions not reported in Heating and cooking		58,900		51,800,000
Open flames and sparks		58,400		77,000,000
Sparks on roof	10,300		5,600,000	
Welding and cutting	6,400		20,000,000	
Sparks from machinery, friction	6,600		12,100,000	
Thawing pipes	3,600		4,100,000	
Miscellaneous open flames and sparks	31,500		35,200,000	
Lightning		25,500		30,300,000
Children and matches		38,600		26,800,000
Exposure		28,700		33,100,000
Incendiary, suspicious		23,900		30,900,000
Spontaneous ignition		20,000		25,300,000
Gas fires and explosions not reported in Heating and cooking		10,700		16,400,000
Explosions, miscellaneous and unclassified		4,500		24,200,000
Fireworks		2,000		1,000,000
Miscellaneous known causes		32,800		48,200,000
Unknown or undetermined		51,900		343,800,000
TOTALS		890,200		$1,139,700,000

Table VI. Estimated Distribution of U. S. Fire Losses by Occupancies, 1960

These estimated figures are intended to show the relative order of magnitude of fire losses by occupancies, and while they are reasonable approximations based on the experience in typical states, they should not be taken as exact records for each class. As explained in the text, 100 per cent has been added in estimating the number of fires, and 33⅓ per cent has been added to the losses to cover unreported losses. Any reproduction of these figures should identify them as "National Fire Protection Association estimates."

	No. of Fires		Losses	
PUBLIC ASSEMBLY OCCUPANCIES		27,200		$ 74,100,000
Amusement, recreation halls	1,200		6,400,000	
Auditoriums	600		1,500,000	
Bowling alleys	1,200		9,100,000	
Churches	3,100		14,700,000	
Clubs, club houses	2,000		6,700,000	
Restaurants, taverns	15,600		25,900,000	
Terminals, passenger	900		2,300,000	
Theaters, incl. motion picture	800		4,700,000	
Other public assembly buildings	1,800		2,800,000	
EDUCATIONAL OCCUPANCIES		4,300		23,400,000
Schools	3,000		16,100,000	
Colleges and other educational buildings	1,300		7,300,000	
INSTITUTIONAL OCCUPANCIES		2,600		3,000,000
Homes for the aged	400		500,000	
Hospitals	1,500		1,500,000	
Other institutional buildings	700		1,000,000	
RESIDENTIAL OCCUPANCIES		627,100		415,800,000
Apartments	35,400		36,400,000	
Dwellings, one- and two-family	563,000		346,200,000	
Hotels	10,200		16,000,000	
Motels	2,200		1,600,000	
Rooming, boarding houses	3,900		2,100,000	
Summer cottages, camps	4,400		2,600,000	
Trailers, trailer courts	7,100		8,500,000	
Other residential buildings	900		2,400,000	
MERCANTILE OCCUPANCIES		39,700		104,500,000
Clothing, dry goods stores	1,100		14,900,000	
Drug stores	900		1,300,000	
Food stores, incl. supermarkets	3,000		18,400,000	
Furniture stores	1,200		12,800,000	
Laundries, self-service	2,200		3,500,000	
Service stations	4,300		6,300,000	
Shoe, shoe repair stores	1,300		700,000	
Other mercantile buildings	25,700		46,600,000	
OFFICE OCCUPANCIES		8,700		21,200,000
Government buildings	2,400		8,500,000	
Office buildings, banks, other office occupancies	6,300		12,700,000	

(Continued on page 221)

Table VI. Continued

INDUSTRIAL OCCUPANCIES		47,900		198,400,000
Chemical, chemical products	2,300		19,600,000	
Food, food products	7,600		30,900,000	
Bakeries	700		1,400,000	
Dairies, creameries	1,600		4,600,000	
Flour mills	1,500		8,900,000	
Meat packing	1,000		2,600,000	
Other food processing	2,800		13,400,000	
Metal, metal products	2,600		15,900,000	
Minerals, mineral products	500		1,800,000	
Paper, paper products	1,500		3,600,000	
Photography, printing	700		7,200,000	
Textiles, textile products	8,600		15,200,000	
Wood, wood products	3,900		26,800,000	
Other industrial operations	9,600		18,900,000	
Dry cleaning plants	1,100		1,700,000	
Electric generating plants, substations, Transformers	1,000		7,200,000	
Garages, repair and public parking	4,900		5,100,000	
Laundries	2,600		4,900,000	
Other industrial buildings and occupancies not reported	10,600		58,500,000	
STORAGE OCCUPANCIES		111,100		213,700,000
Barns	31,800		83,400,000	
Farm property, other	43,500		21,500,000	
Garages, residential parking	22,300		19,700,000	
Grain elevators	2,300		32,100,000	
Grain, feed, seed, hay storage	1,700		7,000,000	
Lumberyards	1,900		9,300,000	
Petroleum bulk plants	600		1,700,000	
Other storage buildings	7,000		39,000,000	
OTHER BUILDINGS, OCCUPANCIES NOT REPORTED		21,600		85,600,000
TOTAL (BUILDING FIRES)		890,200		$1,139,700,000
OTHER THAN BUILDING FIRES		1,233,660		404,500,000
Brush, rubbish, grass	878,700		.....	
Forest fires	103,400		179,100,000	
Other outdoor fires	9,300		6,800,000	
Aircraft	160		125,000,000	
Construction equipment, farm tractors	7,800		6,800,000	
Motor vehicles	229,500		22,900,000	
Railroad rolling stock, incl. all railroad property	3,600		13,600,000	
Ships and other transportation fires	1,200		50,300,000	
GRAND TOTAL		2,123,860		$1,544,200,000

Table VII. Fires per 1000 Population and Fire Loss per Person for Twenty-five States, 1960, as Reported by Fire Marshals

State	Population April 1, 1960	No. of Fires	Fires Per 1000 Pop.	Fire Loss	Fire Loss Per Person
Connecticut	2,535,234	2,711	1.07	$ 9,854,417	$3.89
Delaware[10]	446,292	5,037	11.29	2,869,827	8.19
Illinois[1]	10,081,158	15,668	1.55	36,805,869	3.65
Iowa	2,757,537	3,030	1.10	11,488,293	4.17
Kansas	2,178,611	2,800	1.29	5,736,787	2.63
Kentucky	3,038,156	5,436	1.79	19,323,076	6.36
Louisiana	3,257,022	8,041	2.47	18,058,574	5.54
Maryland	3,100,689	8,722	2.81	12,840,599	4.14
Massachusetts	5,148,578	13,614	2.64	41,522,079	8.06
Michigan	7,823,194	60,833	7.78	40,978,106	5.24
Minnesota[7]	3,413,864	3,762	1.10	17,142,355	5.02
Montana	674,767	1,164	1.73	2,667,920	3.95
Nebraska	1,411,330	2,147	1.52	5,681,553	4.03
New Hampshire	606,921	1,271	2.09	7,935,065	13.07
New Mexico	951,023	6,742	7.09	3,648,705	3.84
North Dakota[2,3,4,6]	632,446	956	1.51	2,908,103	4.60
Ohio	9,706,397	17,875	1.84	39,862,369	4.11
Oregon[3,4]	1,768,687	15,503	8.77	16,618,901	9.40
Rhode Island[6,9]	859,488	1,865	2.17	4,128,036	4.80
South Dakota[1]	680,514	1,444	2.12	4,014,393	5.90
Texas[3]	9,579,677	11,000	1.15	41,135,064	4.29
Vermont[1,3,4]	389,881	851	2.18	2,526,037	6.48
West Virginia	1,860,421	.....	...	4,755,663	2.56
Wisconsin	3,951,777	24,309	6.15	20,130,705	5.09
Wyoming	330,066	2,121	6.43	2,641,446	8.00
	77,183,730	216,902	2.81	$375,273,942	$4.89

[1] Fiscal year ended June 30, 1961.
[2] Fiscal year ended June 30, 1960.
[3] Insured losses only.
[4] Number of insurance claims.
[5] Fiscal year ended September 30, 1960.
[6] No losses less than $100.
[7] No losses less than $25.
[9] Includes insurance losses not reported to fire departments.
[10] Fire loss and fire loss per person exclude the city of Wilmington.

(*Continued from page 214*)

number of fires and loss by cause in 17 and 12 states, respectively.

Tables V and VI, showing the nationwide distribution of fires and losses by cause and occupancy, are based primarily on typical state experience enumerated in Tables I to IV. Table VII summarizes statistics from all state reports received.

Various sources have furnished figures for items in Table IV. Railroad losses were furnished by the Association of American Railroads, Operating-Transportation Division. Statistics on aircraft fires were compiled by reference to the NFPA aircraft fire loss records. Motor vehicle, and rubbish, grass, and brush fire data are based on the annual NFPA survey of U. S. cities (Fire Record of Cities, April 1961 QUARTERLY). The estimate of the number of forest fires was compiled by the Forest Service of the United States Department of Agriculture.

As will be seen in Table VII, 25 states with a population of 77,183,730 reported a total of 216,902 fires. Experience indicates that this is less than half the actual number of fires in these states.

Some states, for example, do not report fires with uninsured losses, others report only fires with losses in excess of $100.

To obtain national estimates of the number of fires by occupancy, 100 per cent was added to the number reported by the 17 states shown in Table I. Making use of this figure and population ratios, the number of fires by occupancy in the United States was calculated. Further adjustments were made based upon other surveys of 1960 fire experience. Following a similar procedure with the state experience shown in Table III, national estimates of the numbers of fires by cause were obtained.

To obtain the estimated national fire loss by occupancy and cause, the population ratio was applied to the loss of the states shown in Tables II and IV. To account for losses not reported through the usual channels, 33⅓ per cent was added as in the previous years. Further adjustment was necessary in a few instances because of the unusually large damage caused by the 1960 large loss fires.

Improved Occupancy List

It is hoped that the occupancy listing used in Table VI will serve as a useful guide to those classifying fires by occupancy. Further occupancy breakdown within major groups will be made in this annual report when statistically significant data become available.

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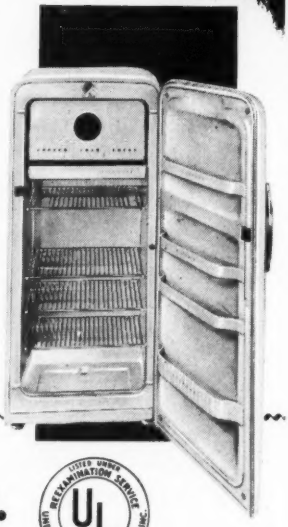

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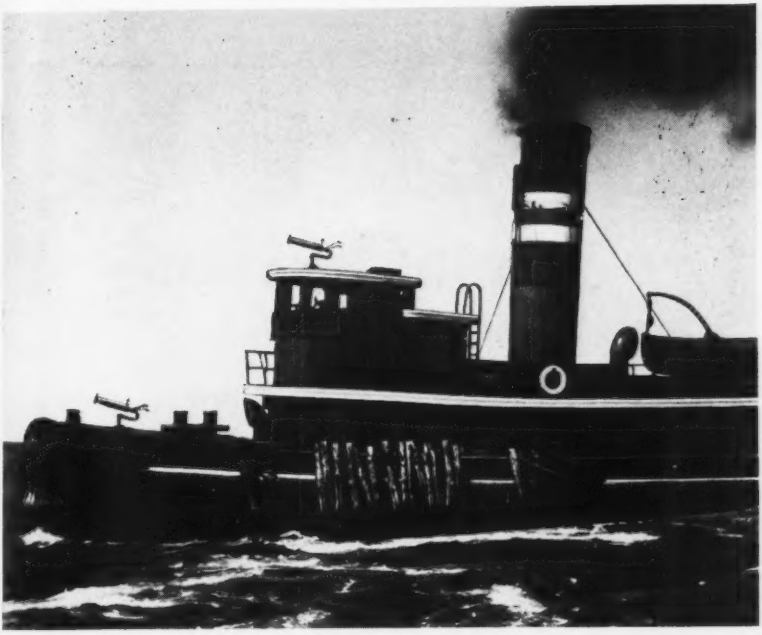

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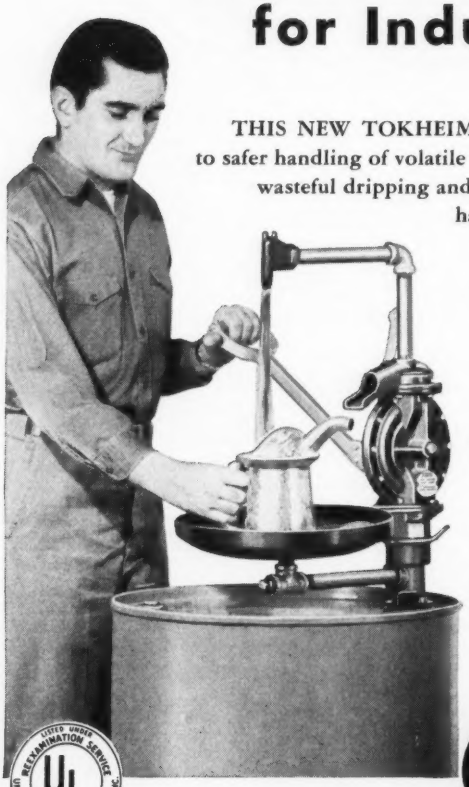

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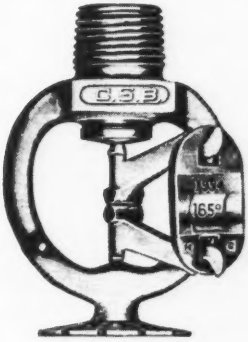

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Ordinary		Color Bronze	165°
Intermediate		Color White	212°
Hard		Color Blue	280°
Extra Hard		Color Red	360°

Our extreme care in manufacture is for your protection

C. S. B. SPRINKLER COMPANY

LACONIA, NEW HAMPSHIRE

Nation Wide
Central Station Protection Services

Sprinkler Valve Alarm — Complete Sprinkler Supervisory — Manual Fire Alarm — Automatic Fire Alarm — Temperature Alarm — Oil Burner Supervision — Burglar Alarm — Hold-Up Alarm — Vault & Safe Protection

Available from these members of

Central Station Electrical Protection Association

ALBANY, NEW YORK	ALBANY PROTECTIVE SERVICE 99 Jay Street
BOSTON, MASS.	CALL'S CENTRAL STATION ALARMS 69 Washington Avenue, Chelsea
CHICAGO, ILLINOIS	CENTRAL WATCH SERVICE 214 West Ohio Street
CLEVELAND, OHIO	MORSE SIGNAL DEVICES 6707 Carnegie Avenue
DALLAS, TEXAS	SMITH DETECTIVE AGENCY & NIGHTWATCH SERVICE, INC. 610 N. Akard Street
DAYTON, OHIO	DAYTON ELECTRONICS ALARM & SIGNAL CO. 301 West Monument Avenue
DENVER, COLORADO	DENVER BURGLAR ALARM COMPANY, INC. 422-21st Street
DETROIT, MICHIGAN	MICHIGAN STILL ALARM CO. 10410 W. Chicago Blvd.
HONOLULU, HAWAII	CENTRAL ALARM COMPANY, LTD. 1755 Kapiolani Boulevard
HOUSTON, TEXAS	McCANE-SONDOCK ALARM SYSTEMS 1612 Austin Street
LOS ANGELES, CALIF.	MORSE SIGNAL DEVICES OF CALIFORNIA 211 So. LaBrea Avenue
MANCHESTER, N. H.	GRANITE STATE ALARM INC. 839 Elm Street
MILWAUKEE, WIS.	MERCHANTS POLICE SIGNAL & ALARM CO. 429 W. Michigan Street
MINNEAPOLIS, MINN.	AUTOMATIC ALARM CORP. 2404 Lyndale Avenue, South
NEWARK, NEW JERSEY	NEWARK DISTRICT TELEGRAPH CO. 372 Plane Street
NEW YORK, NEW YORK	CENTRAL STATION SIGNALS, INC. 53 West 23rd Street
PEORIA, ILLINOIS	PROTECTION ALARMS, INCORPORATED 725 West Main Street
PHILADELPHIA, PENNA.	OWL PROTECTIVE CO., INC. 120 No. Camac Street
PHILADELPHIA, PENNA.	ROBINSON ELECTRONIC SUPERVISORY CO. 15th and Chestnut Streets
ST. LOUIS, MISSOURI	POTTER ELECTRIC SIGNAL & MFG. CO., INC. 1211 Pine Street
SAN FRANCISCO, CALIF.	PACIFIC FIRE EXTINGUISHER CO. AMERICAN BURGLAR ALARM DIVISION 165 Jessie Street
WASHINGTON, D. C.	FEDERAL ENGINEERING CO., INC. 1004 Sixth Street, N.W.

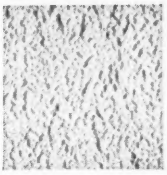
INCOMBUSTIBLE CEILINGS
—*and they're ALL* by "CELOTEX"

Here are some examples of "Ceilings by Celotex" that meet building code requirements for incombustibility.

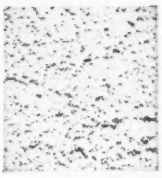
ALL ARE U. L. LISTED

FISSURED MINERAL FIBER TILE

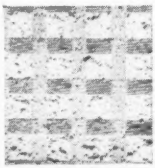
STRIATONE*



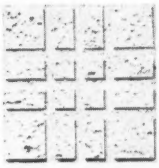
TEXTURE-TONE*



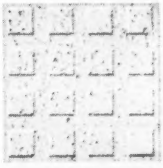
CELOTONE®



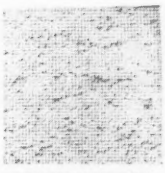
"DESIGN" CELOTONE® Plaid



"DESIGN" CELOTONE® Monarch



"DESIGN" CELOTONE® Empress



"DESIGN" CELOTONE® Modulo

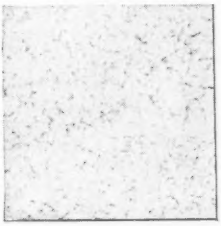
PROTECTONE* MINERAL FIBER TILE

FOR UL FIRE-RATED CEILING ASSEMBLIES

A family of fire-rated acoustical tile and panels. Natural-fissured and perforated patterns.

Above: TIFFANY pattern.

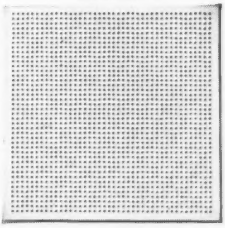
GLASS FIBER PANELS



SUPRACOUSTIC®

*TRADE MARK

GYPSUM BOARD ASSEMBLY



CAVITY TILE†

†U. S. PAT. NO. 2,636,806

If it's "by CELOTEX" you get QUALITY... *plus!*

Acousti-CELOTEX
REGISTERED U.S. PAT. OFF.
SOUND CONDITIONING PRODUCTS

Products to Meet Every Building Code • THE CELOTEX CORPORATION • 120 S. LA SALLE ST., CHICAGO 3, ILL.
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REEVE

HEAVY DUTY ALARM BELLS

GONGS and BUZZERS

Weatherproof

Watertight

Weatherproof —
Sizes 3", 4", 6", 8", 10", 12"
DC—6—220 V. · AC—12—220 V.

Watertight —
Sizes 3", 4", 6", 8", 10", 12"
DC—6—220 Volt · AC—12—220 Volt
60 Cycles, 110—220 Volt, 25 Cycles

3 TYPES OF
UNDERDOME BELLS
OPEN PIGTAIL · WEATHERPROOF · E-Z MOUNT
Sizes 6", 8", 10". Cast aluminum housing
Hot Pressed Steel Gong Shell
Single Stroke and Vibrating Types
Voltages are the same as Neck Type

Special Windings on request.

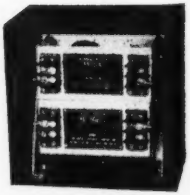
Seal of approval by UNDERWRITERS' LABORATORIES · FACTORY MUTUAL LABORATORY, INC. · UNITED STATES COAST GUARD

Write for Catalog Material and Prices!

AUTOMATIC BATTERY CHARGER, High and Low Current

The unit is designed for use on any storage batteries not subject to heavy drains. It will trickle charge the battery indefinitely because of its automatically decreasing rate of charge.

For use with six cells (12 volts). Automatically controlled by saturable reactor. Continuous output one ampere. 22.5 watts, 118 volts, 60 cycles. 3% Regulation. 9" x 9" x 6" — 14 B & S gauge steel wall cabinet. 15¼ lbs. U.L. Approved. No moving parts.



MODEL BC-12

Manufacturers of a complete line of

CENTRAL OFFICE and LOCAL FIRE ALARM DEVICES

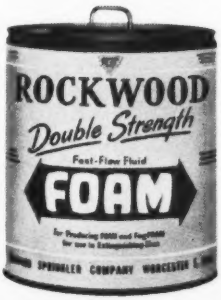
· automatic alarm devices · sprinkler alarm and supervisory devices · burglar alarm devices and accessories. DYNALARM (sound detection for both reverberant and non-reverberant vaults).

THE REEVE ELECTRICAL CO., Inc.
120 West 42nd Street, New York 36, N.Y.

99.7%

of Rockwood FOAM protection

is FREE!



FOR FIRE FIGHTING purposes Rockwood Double Strength FOAM is inexpensive and completely effective. 3 parts *Rockwood Foam Liquid, plus 97 parts free water, plus 900 parts free air give you a fast low-cost fire extinguishing agent for only 1½ cents a gallon!*

Rockwood Double Strength FOAM puts out fires fast . . . reduces your storage costs . . . reduces shipping costs too! If you're using other types of special hazard fire extinguishing agents — you may not be using the most economical or most effective agent! We'll show you how to save on training cost and on fire fighting costs — and to fight fires better! Send for complete information today to Rockwood Sprinkler Company, Portable Fire Protection Department, 3004 Harlow Street, Worcester 5, Massachusetts. Tested and listed by Underwriters' Laboratories, Inc. Distributors in all principal cities. Rockwood Sprinkler Company, A Division of The Gamewell Company, A Subsidiary of E. W. Bliss Company.

ROCKWOOD

PORTABLE FIRE FIGHTING EQUIPMENT

MH

Roll-call for water

the DEMON FIRE

Some of the largest and most modern water works systems in the U.S. are located here in the east-north-central States. It is hard to believe that here 90 years ago, a sprawling, shambling frontier city built of wood, practically burned to the ground when Mrs. O'Leary's cow kicked over a lantern. The Chicago Fire in 1871 was one of the first great disasters of U.S. history. It destroyed $200 million in property and took 250 lives.

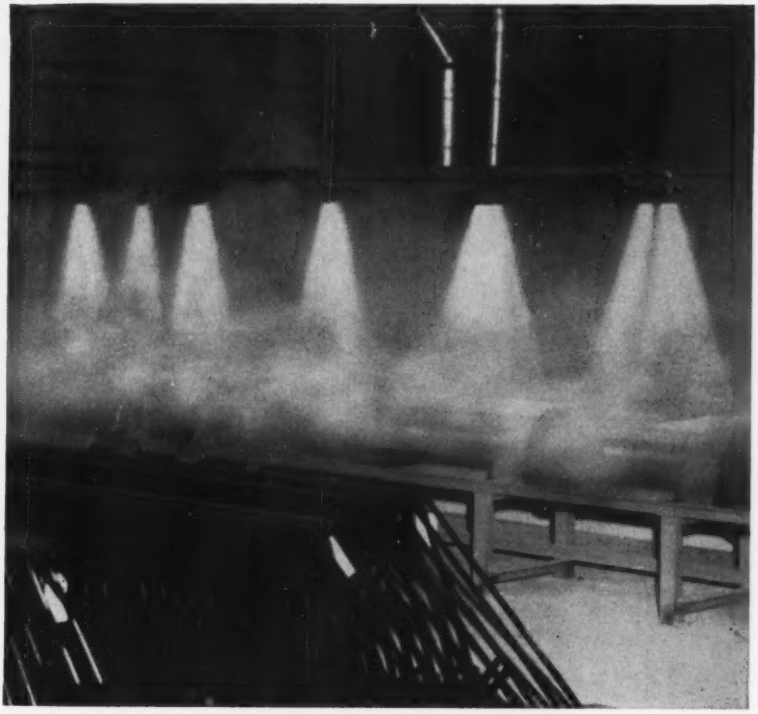
U.S. Department of Commerce lists 85 midwest cities today as having adequate and efficient water works, with an overload capacity 20% in excess of maximum-day load. But the Department also lists 16 midwest water works as inadequate and 18 additional water systems as definitely deficient! Here lives some 15 million Americans – But over 3 million of them have inadequate water supply facilities!

Annual property loss from fire in the U.S. in 1959 was in excess of 1 billion dollars. At the same time, approximately half of the water works facilities of the U.S. are inadequate or deficient in capacity. Considering present water distribution deficiencies and increasing demand due to population growth, it is estimated that water supply facilities will need to be doubled within the next 20 years.

Ohio
Indiana
Illinois
Michigan
Wisconsin

M&H VALVE
AND FITTINGS COMPANY
ANNISTON, ALABAMA

A WALWORTH SUBSIDIARY



What put out the flo-coat and drier fire?

For fires in flo-coaters, driers, quench tanks, dip tanks, storage rooms . . . nothing beats a Kidde fully automatic carbon dioxide fire extinguishing system. U.L. and F.M.-approved Kidde systems go into action at the first sign of a blaze, snuff out fire in seconds, leave no mess to clean up later. Protect yourself by protecting volatile solvents, gases, flammable liquids—*all hazards*—with an automatic Kidde system. Kidde's 40 years' experience can help you guard any fire hazard. Write today and find out how.

Kidde (K Kidde)

Industrial and Marine Division
Walter Kidde & Company, Inc.
1051 Main St., Belleville 9, N. J.
Walter Kidde & Company of Canada Ltd.
Montreal — Toronto — Vancouver

CENTRAL STATION SIGNALS, INC.

Manufacturers of all kinds of approved devices used in Central Station Systems or Class 'A' or Class 'B' Proprietary Fire Alarm Systems, either automatic or manual.

53 WEST 23rd STREET . . . . . NEW YORK 10, N. Y.

5-inch size shown above. To install simply drill 2-inch hole in pipe.

Model PRS-1

Sprinkler Waterflow Alarm

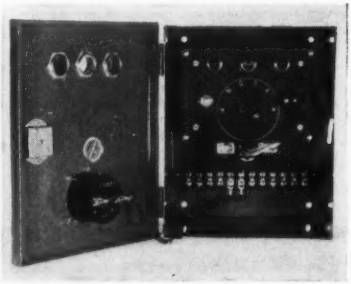
This device is approved by Factory Mutual Laboratories and Underwriters' Laboratories, Inc.

- This device is also made as Model PRT-1, a coded waterflow transmitter.

- Also made in explosion proof models.
- Made in all sizes from 2½" to 8".
- Has instantly recycling pneumatic retarding device, preventing false alarms.
- Has enclosed electrical contacts for any voltage not exceeding 15 amp. 125 volts, A.C. and ½ amp. 125 volts, D.C. Operates on all water pressures or surges.

Proprietary & Remote Panels For Fire Headquarters

This Fire Headquarters Unit is designed to be used primarily for the receipt of signals at a remote station when actuated by a local alarm unit in the protected premises. It is electrically supervised and will give a trouble signal in case of open and ground and will also receive an alarm under these conditions. This panel is made for 12 or 24 volt D.C. operation.



Local Non-Coded Fire Headquarters Unit

Flintkote • Van-Packer Model HT Smokestack is UL-listed... ideal for incinerators & boilers

Wherever you see a Flintkote • Van-Packer Model HT Smokestack specified for incinerators, boilers or furnaces, you can be sure it will provide safe, reliable service. It is listed under the Factory Inspection and Label Service Program of Underwriters' Laboratories, Inc.

Van-Packer Smokestacks are erected from factory-built, insulating refractory sections. Each 3-foot section is encased in a corrosion-resistant metal outer jacket. Joints are sealed with acid-proof cement and secured with corrosion-resistant draw-up type joint bands assuring utmost strength and safety.

Model HT Smokestacks safely handle industrial incinerator flue gas temperatures up to 1800°F and up to 2000°F for occasional brief periods of forced firing. They won't corrode and average three times greater life than steel stacks. Insulating qualities of refractory wall prevent heat loss, give draft equal to brick and greater than steel.

Write for data file giving full information on Flintkote • Van-Packer Smokestacks

FLINTKOTE VAN-PACKER®

Division of The Flintkote Company
Manufacturer of Diversified Products for Home and Industry

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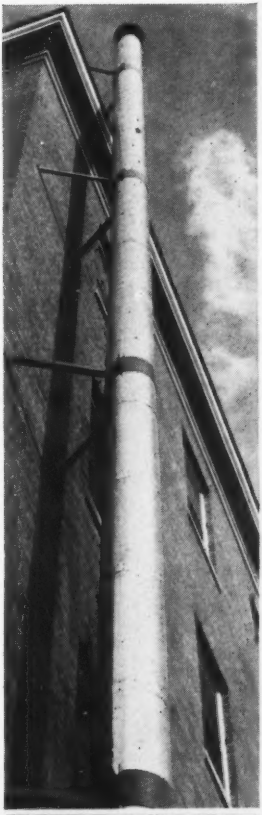
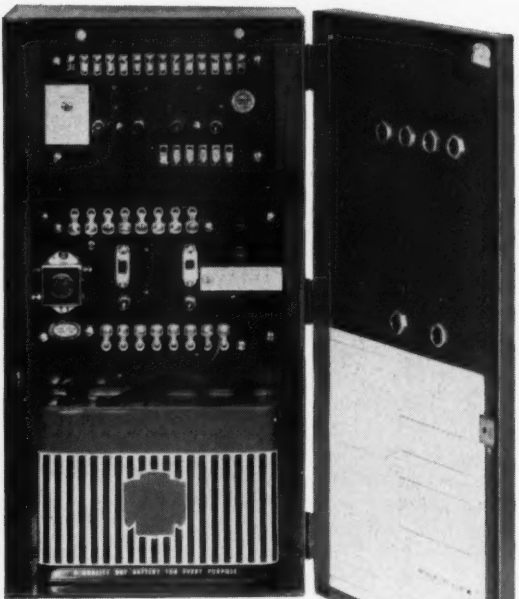


Underwriters' Laboratories, Inc.®
INSPECTED
Van-Packer Model HT Smokestack

In the West: Pioneer Division, The Flintkote Company, Box 2218, Terminal Annex, Los Angeles, Calif.

In Toronto, Ontario: The Flintkote Company of Canada, Ltd.



19" high

NEW!

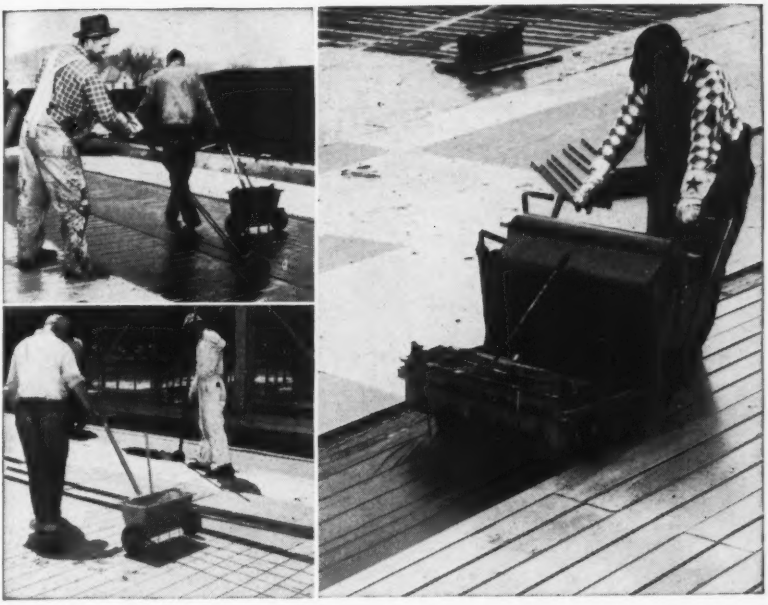
Fire Alarm Control Cabinet

Kidde's new compact automatic fire alarm combination panel monitors four circuits with local alarm. A one-circuit cabinet is also available with or without the 4-zone annunciator. Any number of detectors and noncode break-glass stations can be used with the new cabinet, and a locking-type alarm relay permits the use of self-restoring detectors or stations. The unit provides for two vibrating bell circuit terminals.

U.L.-approved, the new Kidde unit draws power from any 120 volt AC source and converts it to 6 volts DC for operation. In case of power failure, a trouble alarm sounds, and the entire system automatically transfers to self-contained battery operation. For more information, write to Kidde.

Kidde

Kidde Ultrasonic & Detection Alarms Division, 1051 Brighton Road, Clifton, N. J.
Walter Kidde & Company, Inc.



Pictures. (Right.) Lexsuco Applicator applies vapor barrier and adhesive for large jobs in a 3 in 1 operation. (Top left.) For smaller jobs, the semi-mechanical method is used to apply vapor barrier and adhesive with Spreader and Roller Coater. (Bottom left.) Lexsuco Spreader applies adhesive to secure insulation.

LEXSUCO
ROOF CONSTRUCTIONS

Engineered Applications Save Time and Money

LEXSUCO'S engineered application methods cut labor costs and speed up work in applying Lexsuco Fire-Retardant Roof Constructions on large or small jobs. Lexsuco products are reliable and job proven.

Remember, with or without a vapor barrier, Lexsuco Roof Constructions provide assured fire protection as tested and accepted by Factory Mutual Engineering Division and Underwriters' Laboratories, Inc. Write us for complete information or call your Lexsuco Representative.

- Assured Fire Protection
- More for Your Roofing Dollar
- Lower Insurance Premiums
- Engineered Application
- Better Roof Construction

LEXSUCO INC

BOX 326 • SOLON, OHIO

Pioneers in Fire-Resistant Roof Constructions

The
"MINUTE MEN"
of FIRE PROTECTION

UPRIGHT MODEL SSU
Write now for
complete information

GRIMES SPRINKLERS
stand guard over your life and property 24 hours of every day, year after year after year. It is comforting to know they are always dependable and ready to go into action at a minute's notice! GRIMES Fire Sprinkler Systems and Equipment are engineered for better protection.

Through the years, GRIMES has earned a reputation for designing, developing and manufacturing the newest and most improved sprinkler equipment available.

GRIMES devices are approved by all insurance interests everywhere. Learn how much modern engineering can do for safe, sure fire protection and how the cost of GRIMES installations pay for themselves out of savings in insurance premiums in comparatively short periods of time.

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SPRINKLER DIVISION

RAISLER CORPORATION, 750 Third Ave., New York 17, N.Y.
Licensees in all principal cities in the United States and Canada

MAHON
automatic
ROLLING-STEEL
FIRE DOORS

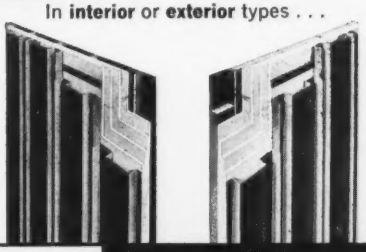
Quick-acting Mahon Fire Doors (and Fire Shutters) are engineered, built and installed for your maximum advantage and safety. No other fire door offers you as much—Underwriters' Label, vertical roll-up action, manual or power operation with automatic fire closing, Bonderized slats, ruggedly made—and more. Investigate the many diverse benefits . . .

send for Catalog G-61

FOR BASIC FIRE PROTECTION

In **interior** or **exterior** types . . .

MAHON
underwriters' rated
METAL-CLAD
FIRE WALLS



Univ. of Michigan Hospital uses Mahon exterior Fire Wall in this elevated walkway

Mahon Fire Walls are a superior fire-protection product—rated at two or three hours—for use as interior dividers or exterior curtain-type wall. There is a type for your use . . . your architecture . . . your safety demands. For full information on these versatile panels . . .

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THE R. C. MAHON COMPANY
DETROIT 34, MICHIGAN
Manufacturing Plants—Detroit and Torrance, Calif.
Sales Offices—Detroit, New York, Chicago San Francisco, Torrance, Cleveland and E. Orange, N. J.
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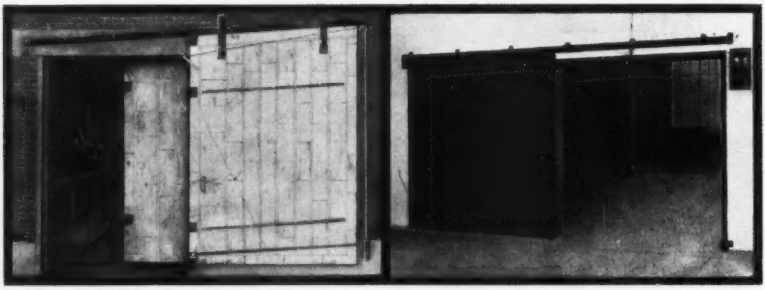
MAHON

New D & H SLIDING FIRE DOORS Mean

ONE instead of TWO

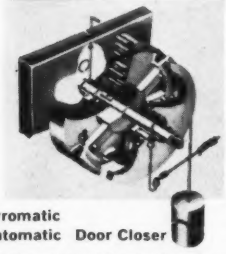
Under New 1961 Uniform Building Code for Fire Walls in Buildings



OLD TYPE DOORS. Two sliding metal clad fire doors are required for protection of 3-hour fire wall openings according to the 1961 Uniform Building Code (Int'l Conference of Bldg. Officials). Unattractive, cumbersome.

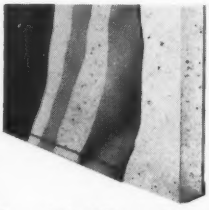
NEW SLIDING PYRODOR. After passing an official fire and hose stream test for 3-hr. rating, a SINGLE "SL" Pyrodor has been approved for 3-hr. walls under 1961 Uniform Bldg. Code standard 43-2-61 (guide card 1404.1). New flush design, pleasing appearance and automatic operation.

Outstanding Features of the D & H SLIDING PYRODOR



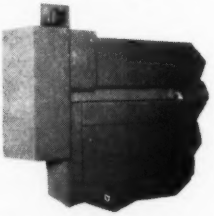
Pyromatic Automatic Door Closer

First automatic device approved and labeled by Underwriters' Laboratories. Smooth, easy manual operation at all times . . . yet fully automatic, at controlled speed, in event of fire.



Lowest Heat Transmission Solid Mineral Core

Unequalled by any other fire door construction. Impervious to moisture and dry rot . . . dimensionally stable . . . warp proof.



New Underwriters' Labeled Anti-Creeping Device

Wedging open fire doors no longer a problem. Door is held fully open . . . releases automatically.

Smooth, flush-designed Sliding PyroDors are ruggedly constructed by combining heavy gauge zinc coated and bonderized Stretcher-Leveled Steel with a solid mineral core.

Write for 8 Pg. D & H Sliding PyroDor Catalog . . . or Consult Sweet's File or the Yellow Pages for Your Nearest D & H Distributor

DUSING & HUNT, Inc.

67 LAKE ST., N. LE ROY, N. Y.

IF YOU'VE BEEN WAITING FOR A RELIABLE

FIRE EXTINGUISHING AGENT...

and the right extinguishers to go with it...then "FORAY" was designed for you! "FORAY" is the name of the new Ansul line of dry chemical extinguishers for *all* classes of fires—and the A-B-C extinguishing agent itself. Available in six popular models: 10's, 20's and 30's in both *cartridge* and *stored pressure*. Planned obsolescence? Never... "FORAY" conversion kits for your present Ansul extinguishers are readily available. Call your local Ansul Man...he's listed in the "Yellow Pages."

ANSUL CHEMICAL COMPANY, MARINETTE, WISCONSIN

"FORAY" extinguishers (both cartridge and stored pressure) carry these Underwriters Laboratories ratings: Model 10: 1A-16B:C, Model 20: 3A-20B:C, Model 30: 4A-20B:C

NOW... Kuhns ductile iron fittings

For Sprinkler Systems

Kuhns ductile iron pipe fittings—the newest development in piping—provide an extra margin of operating safety for sprinklers, high pressure lines and other vital piping systems. High structural strength and resistance to thermal shock help these fittings prevent leakage caused by vibration, temperature changes or misalignment.

"K" Pipe Lock Couplings

Listed for 800 psi by Underwriters' Laboratories, Inc., these couplings have a safety factor of five times the UL listing for 2½" through 6" and four times UL listing for 8". Sizes: 2½" through 8". Look for the "800 D" on each.

"K" Flanges and Flanged Fittings

Pressure rating, 500 psi by Underwriters' Laboratories, Inc. for elbows, base elbows, 45° elbows, side outlet elbows, tees, side outlet tees, and reducers in straight and reducing sizes. Flat faced flanges standard. Extra heavy flange dimensions and raised faces available. Look for the "DI 500" on each.

Complete range of sizes through 12".

"K" Screwed Fittings *

Pressure ratings listed by Underwriters' Laboratories, Inc.

STEAM AND OIL AT 550°F

¼" to 3".....300 lbs.

LIQUID AND GAS AT 150°F

¼" to 1".....2000 lbs.

1¼" to 2".....1500 lbs.

2½" to 3".....1000 lbs.

*Ductile iron fittings are available in any size in Kuhns complete cast iron line, ¼" through 12".

Note: These fittings are excellent for liquefied petroleum gas systems. Look for the "DI 300" on each.

Send for our catalog or contact your wholesaler.

THE KUHNS BROTHERS CO.

1800 McCALL STREET, DAYTON, OHIO

STARGARD

Ceiling Pattern (Flush-Type) Automatic Sprinklers

☆ DECORATIVE

☆ DISTINCTIVE

☆ DEPENDABLE

THE ULTIMATE IN FIRE PROTECTION

STAR SPRINKLER CORPORATION

Westmoreland & Collins Sts., Phila. 34, Pa.

Licensees in principal cities of the United States and Canada

AUTOCALL FIRE ALARM SYSTEM SAFEGUARDS NEW BANK OF GEORGIA BUILDING

This modern new 31-story commercial building in the heart of Atlanta is unique. In addition to being the tallest building in the southeast, it is the highest reinforced concrete structure in the U.S.A.

Equally modern is its fire protection system. 61 strategically located fire alarm stations combine with an Autocall DNS system with Annunciator Panel for instant and continuous alarm. This control panel visually shows the floor of the originating signal for immediate fire-fighting action.

This completely supervised system also sounds a trouble bell if an open or grounded condition should occur.

Experienced Autocall district representatives are prepared to work closely with you in planning and engineering protection systems for every type of property. There is absolutely no obligation for this service. Write, wire or phone: The Autocall Company, Shelby 5, Ohio.

Autocall®

SAFEGUARDS MILLIONS

stop fire
at all openings with—
AKBAR
The famous automatic Steel Rolling Fire Door with positive acting Push-Down Spring made only by Kinnear

This New Bulletin gives you complete information —

— on Kinnear's exclusive AKBAR Steel Rolling Fire Doors, labeled by Underwriters' Laboratories, Inc.

The *Kinnear-originated* door curtain of interlocking steel slats — specially adapted to fire-blocking needs in Akbar doors — offers maximum safety at all openings.

With Akbar, you get *positive, automatic* fire protection. The instant fire causes automatic release, the Akbar curtain is *pushed* downward (*a Kinnear exclusive*) by a strong spring. Closing speed is controlled for safety, and the door is operable *after* automatic release, for emergency exits.

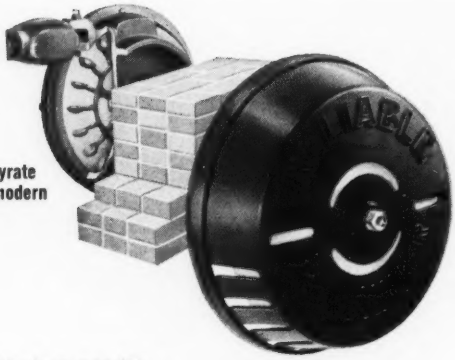
When closed, AKBAR Rolling Fire Doors block drafts, repel flames, keep fire from spreading. Also available equipped for daily service, with motor or manual control. (*Use non-labeled Kinnear Rolling Doors where fire protection is not required.*)

Write for your free copy of this all-new bulletin today.

KINNEAR® ROLLING DOORS
Saving Ways in Doorways

The KINNEAR Manufacturing Co.
Factories: 2250-70 Fields Ave., Columbus 16, Ohio
1742 Yosemite Ave., San Francisco 24, California
Offices and Representatives in All Principal Cities

ONLY RASCO OFFERS THE MODERN LOOK IN AUTOMATIC SPRINKLER ALARMS!



NEW!
Exclusive—Attractive Gong Cover of tough Butyrate Plastic, blends with all modern building architecture.

NEW!
Exclusive—Rugged Aluminum Gong.

NEW!
Exclusive—Plastic and Aluminum materials eliminate rust-streaking.

Reliable Licensees are conveniently located throughout the United States and foreign countries. They're ready to serve you in the design, installation and service of automatic sprinkler protection.

Look to Rasco for Complete Fire Control!

THE RELIABLE AUTOMATIC SPRINKLER CO. INC.

It's NEW*** from NOTIFIER

The

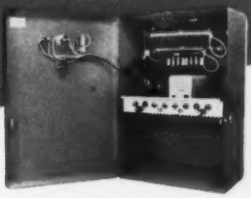
CAFP-1

SINGLE CIRCUIT
120 V-A.C. PANEL

Relay equipment in dust-proof, tamper-proof plug-in units

Alarm bell electrically supervised; Will ring one to ten 12 volt A. C. Bells

Also available as a modular multiple circuit CA Series.



NOTIFIER CAFP-1 A. C. Panel is ideally suited for protection of schools; dormitories; nursing homes; small plants and similar properties where an alarm on the local premises is usually sufficient . . . can be used in conjunction with an auxiliary trip panel for transmitting non-coded or coded alarm signals to a remote station receiving panel.

NOTIFIER CA Series is designed in multiples of 2 to 6 station circuits and 4 to 12 bell circuits mounted in a single cabinet. Expandable to an unlimited number of cabinets.

NOTIFIER ALSO OFFERS:

- **Complete engineering counsel** as part of the package
- **Immediate delivery** on all standard items
- **A full line of superior products** from a firm whose ONLY business is fire detection, prevention and protection

For full information regarding the NOTIFIER CAFP-1 120 volt AC, 60 cycle single circuit panel, write

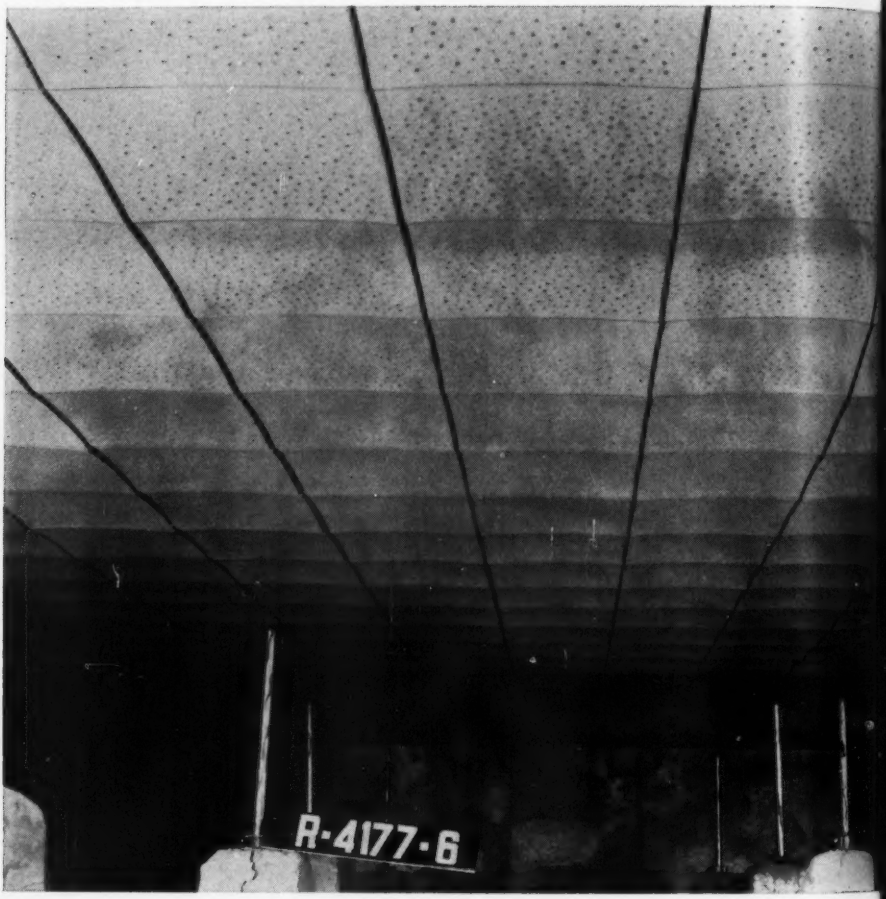
Some Dealerships Available in Good Market Areas

Refer to our catalogs

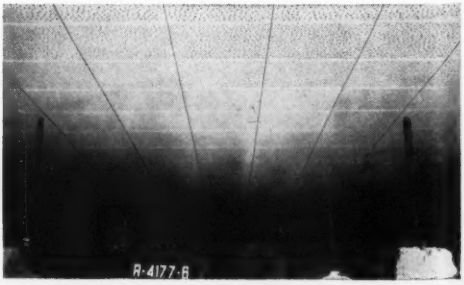
34A NO in Sweets' Architectural File
and
C6 NOT in Sweets' Plant Engineering File

NOTIFIER FIRE ALARM

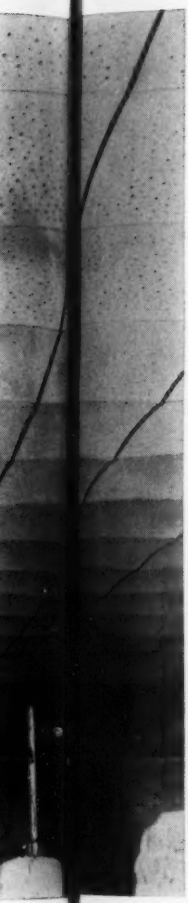
NOTIFIER CORPORATION
3720 North 56th St. Lincoln, Nebraska



The ceiling pictured above is Armstrong Acoustical Fire Guard *after* four hours' exposure to scorching flames and temperatures reaching 2000 degrees (UL test R-4177-6). It graphically shows how the first and most widely tested fire-retardant acoustical ceiling tile protects structural components above from flames and heat—for up to four hours.



Acoustical Fire Guard ceiling installed in actual test furnace, prior to beginning the four-hour UL test.



Here's Armstrong Acoustical Fire Guard after four hours' exposure to scorching flames and temperatures reaching 2000 degrees

THE TEST: This photograph shows the exposed surface of an acoustical ceiling installed in the actual test furnace – *after* four hours' exposure to flames and temperatures reaching 2000 degrees. The ceiling is Armstrong Acoustical Fire Guard after completion of Underwriters' Laboratories, Inc., test R-4177-6.

Exposure to these extreme conditions produced some "dishing" of the tile and separation of joints. But the tongue on Acoustical Fire Guard tile effectively bridged this separation, blocking the passage of flame and resisting the transmission of heat. Protected by the Fire Guard ceiling, the metal suspension system held all tiles firmly in place.

THE RESULT: floor and ceiling design #21, incorporating a ceiling of 12 x 12 inch Acoustical Fire Guard tile, will afford four-hour protection against the passage of flame or dangerous transmission of heat. Other floor-ceiling asemblies using Acoustical Fire Guard tile and the new lay-in ceiling system have earned ratings of from one to four hours. (See table below for UL ratings commonly used to meet code requirements.)

For full details about either Acoustical Fire Guard tile or lay-in units, call your Armstrong Acoustical Contractor (he's in the Yellow Pages under Acoustical Ceilings), or your nearest Armstrong District Office. Or write to Armstrong Cork Company, 4207 Woodbridge Street, Lancaster, Pennsylvania.

HERE ARE SOME OF THE UL RATINGS FOR ACOUSTICAL FIRE GUARD MOST FREQUENTLY USED TO MEET FIRE CODE REQUIREMENTS:

Fire Guard Lay-In		Fire Guard Tile	
Floor and Ceiling Design	Rating	Floor and Ceiling Design	Rating
#30	2 hours (Beam—3 hours)	#31	4 hours
#13	2 hours (Beam—3 hours)	#21	4 hours
#21	2 hours	#8	2 hours
#8	1½ hours	#7	1½ hours
		#9	1 hour

Armstrong ACOUSTICAL CEILINGS

First in Fire-Retardant Acoustical Ceilings

HIGH VALUES · MAXIMUM PROTECTION

"AUTOMATIC" SPRINKLER FOAM-WATER DELUGE SYSTEM

guards $26,000,000 hangars—helps maintain TCA record of customer service!

Trans-Canada Air Lines at its giant new Montreal Overhaul and Maintenance Base chose the "Automatic" Sprinkler Foam-Water Deluge System as maximum protection for the heart of its service facilities, two huge hangars—6 acres of floor space. Every square foot, every jig, fixture, part, every aircraft is guarded by over 3000 foam-water sprinklers ready to discharge fire-smothering foam.

Trans-Canada, in common with many other large transportation and industrial concerns, realizes the importance of protecting high values in equipment and customer relations with fast, reliable, positive protection.

INSTALLATION TEST shows fire-smothering blanket from Foam-Water System (Rate-of-Rise operated) installed by "Automatic" Sprinkler Co. of Canada, Ltd.

BEFORE YOU DECIDE

on protection for your high values against flammable liquid fires, see "Automatic" Sprinkler's new motion picture, "Automatic" Foam-Water Sprinkler Systems. Write today.

"Automatic" Sprinkler CORPORATION OF AMERICA

MANUFACTURERS AND INSTALLERS OF APPROVED FIRE PROTECTION EQUIPMENT

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In Flint, Chief Pratt will tell you

Compactness, Higher Capacity Key Flint's New Gamewell System

"We wanted an up-to-date, highly efficient alarm center in Flint," states Elmer L. Pratt, Chief of that Michigan city's fire department, "and Gamewell gave it to us. Not only is the new Gamewell system tops in efficiency and reliability . . . it actually costs us less than a leased telephone system."

Although Flint's new system has a greatly expanded capacity for additional circuits, it occupies much less space than the old system. It ties together the city's 290 street fire alarm boxes plus master boxes installed in major public buildings, schools, hospitals and industries. Scant seconds after any box is pulled, Flint's entire fire defenses are alerted to the location of the fire.

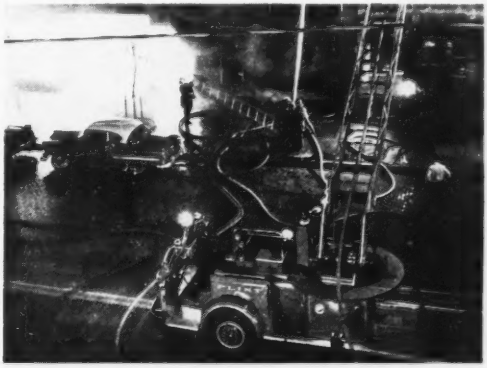
Chief Pratt recalls an incident that dramatically illustrates one of the system's most outstanding features — the fact that it is Three-Fold*. "We had a case where a car knocked out a circuit and burst into flames. A witness ran to the box and sounded the alarm. Though the circuit was broken, the alarm was received at the center. We wouldn't have received that alarm with the old system."

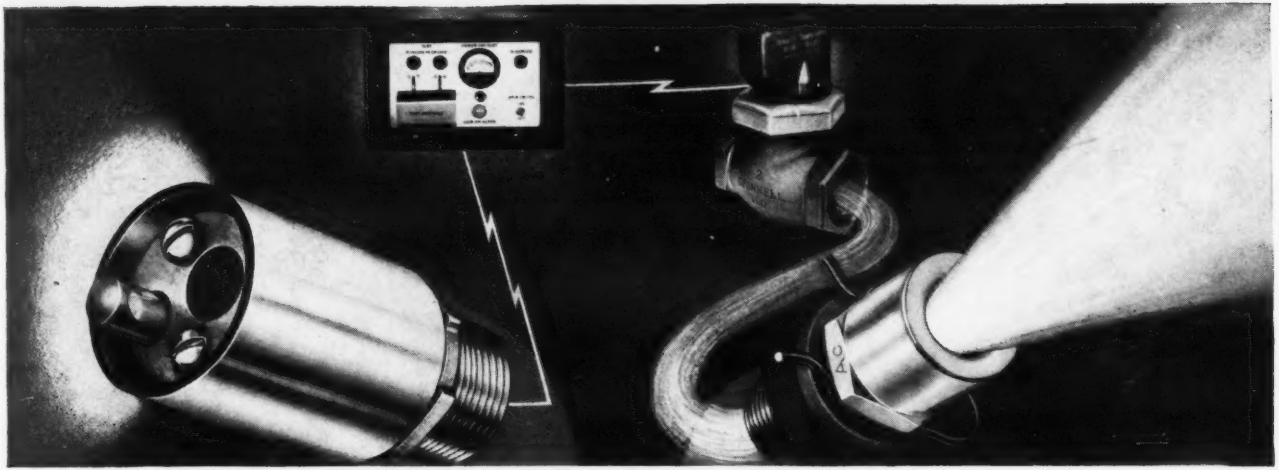
Make certain that your fire safety authorities know what positive steps can be taken toward reducing loss of life and property. Gamewell will be happy to assist you with your fire reporting problems. Write to THE GAMEWELL COMPANY, 1299 Chestnut Street, Newton Upper Falls 64, Massachusetts. A Subsidiary of E. W. Bliss Company.

*T. M. Registered

BLISS Gamewell®

FIRST...WHEN SECONDS COUNT





NEW! SPEED-OF-LIGHT FIRE DETECTION PLUS FASTEST-ACTING SPRAY PROTECTION WITH GRINNELL'S NEW PRIMAC® FIRE-CONTROL SYSTEM*

New Grinnell system detects fire in milliseconds... offers ultra-high-speed protection where solid propellants, other materials present special hazards

Manufacture and use of solid propellants present special fire hazards. Fire protection must be ultra *fast*, if it's to be effective!

Grinnell's Primac fire-control system operates in milliseconds. A photosensitive cell picks up the first light from a fire... transmits a signal that actuates the new Primac water-control valve... and strategically-placed nozzles spray water over the blaze. It's the fastest fire protection system ever devised!

*Patent Pending

If you work with solid propellants — or *any* material that demands ultra-high-speed fire control — Grinnell's new Primac system can give you the protection you need. Each Primac system is specifically designed to fit a particular application. Write for information to Grinnell Company, Inc., Providence 1, Rhode Island.

GRINNELL

AUTOMATIC SPRINKLER FIRE PROTECTION SINCE 1878

fire protection system ever devised!

*Patent Pending

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